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27 Abstract
The third quarterly supplement to SELECTED URBAN STORM WATER RUNOFF ABSTRACTS is a compilation of abstracts summarizing articles from a variety of technical literature concerning the problem of urban drainage published from January 1971 through March 1971. The 89 abstracts covering a range of ten sections are arranged alphabetically by author and numerically by abstract number within each category. Each item includes a bibliographic citation, an abstract, and a set of indexing descriptors and identifiers. A cumulative subject index at the end of the volume provides the necessary access to individual concepts. An author index and a journal list are also included.
This work was submitted in fulfillment of Contract 14-12-904 between the Water Quality Office of the Environmental Protection Agency and the Franklin Institute Research Laboratories.

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Selected Urban Storm Water Runoff Abstracts

Third Quarterly Issue

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SELECTED URBAN STORM WATER RUNOFF ABSTRACTS

Third Quarterly Issue

by

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ABSTRACT

The third quarterly supplement to SELECTED URBAN STORM WATER RUNOFF ABSTRACTS is a compilation of abstracts summarizing articles from a variety of technical literature concerning the problem of urban drainage published from January 1971 through March 1971. The 89 abstracts covering a range of ten sections are arranged alphabetically by author and numerically by abstract number within each category. Each item includes a bibliographic citation, an abstract, and a set of indexing descriptors and identifiers. A cumulative subject index at the end of the volume provides the necessary access to individual concepts. An author index and a journal list are also included.

This work was submitted in fulfillment of Contract 14-12-904 between the Water Quality Office of the Environmental Protection Agency and the Franklin Institute Research Laboratories.

Key Words: Drainage systems, overflow, sewers, storm drains, storm runoff, urbanization, drainage, judicial decisions, legal aspects, planning, publications, rainfall-runoff relationships, runoff, combined sewers, Great Britain, storm overflows, storm sewers, urban hydrology.

FOREWORD

The third quarterly supplement to SELECTED URBAN STORM WATER RUNOFF ABSTRACTS is a compilation of abstracts summarizing articles from a variety of technical publications covering subjects pertinent to the problem of urban drainage.

The present work includes 89 abstracts of documents published for the most part from January 1971 through March 1971. For convenience, the abstracts are classed in ten categories and arranged alphabetically by author and numerically by abstract number within each category. Since most of the papers fit into more than one category, a cumulative subject index at the end of the volume provides the necessary access to individual concepts and should be utilized for locating all abstracts in which this concept is significant. The numbers following an index term are the numbers for the abstracts in which this term is found. Each item includes a bibliographic citation, an abstract, and a set of indexing descriptors (subject terms listed in the WATER RESOURCES THESAURUS November 1966 edition) and identifiers (newly suggested index terms). The most important index terms are marked by an asterisk. An author index and a journal list are included for the reader's benefit.

Copies of the articles abstracted in most cases can be obtained from research libraries covering water pollution or public health engineering literature.

Suggestions concerning the improvement of content and format, or expansion of subject coverage in future supplements will be gratefully received.

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SECTION 1.

Construction: Equipment and Materials; and Instrumentation

087
PREASSEMBLY METHOD SPEEDS STORM SEWER PROJECT,

Public Works, Vol 102, No 2, pp 85, Feb 1971.

Descriptors: *Urbanization, *Drainage systems, *Construction, Pipes, Bolts, Construction equipment.
Identifiers: *Storm sewers, *Preassembly, *Colorado Springs, Colorado.

As a result of rapid urban development in the City of Colorado Springs, improvements in its storm water drainage system are being undertaken. The Burks & Company, Inc. has recently completed the $480,000 construction of an elliptical storm sewer line which has a 13'11" bottom span with a center height of 8'7" and meets the H-20 loading standard requirements. The contractor opted to preassemble most of the line at street level, then used a brace of compact telescoping-boom hydraulic cranes to carry and emplace the sections. Between 85 and 90 percent of the bolting-up work was accomplished at street level and there were only two seams to bolt in the trench due to the fact that the pipe was assembled in bottom and top halves.

088
PREASSEMBLING, CRANE EMPLACEMENT FOR MULTIPLATE STORM-SEWER LINE,

Water Sewage Works, Vol 118, No 2, pp 48-49, Feb 1971.

Descriptors: *Construction, *Construction equipment, *Materials, *Cranes, Labor mobility, Excavation, Safety, Specifications, Construction costs.
Identifiers: *Storm sewers, *Preassembly.

A 3100-foot section of large-diameter storm sewer in Colorado Springs, Colorado was constructed, based on preassembling most of the line at street level then using two telescoping-boom hydraulic cranes to carry and emplace the sections, by Burks & Company, Inc. for an estimated $480,000. Limited easements and tight working quarters made efficient handling with hydraulic cranes a key factor in determining the practicality of the multiplate material and the preassembly method. A 12.5-ton BLH Austin-Western with a 56-ft full power boom and a 15-ton Bantam wing crane unloaded trucks delivering 400 tons of steel, helped with assembly, and delivered and placed the assembled stations of the storm sewer line. Burk's project was part of the $2.8 million Little Shooks Run drainage basin improvements program. The contract called for installation of the multiplate storm sewer line and also covered excavation, backfilling and compaction, installation of catchbasins, and construction of new asphalt roadways replacing

pavement destroyed by the trenching operations. Working with Warner-Swasey Hopto and Lorain backhoes to handle the major part of the excavation, the two crews, one starting in the middle and both working in the same direction, averaged about 52 feet/day of line put into place.

089
THE MEASUREMENT OF THE EFFECTS OF BUILDING CONSTRUCTION ON DRAINAGE BASIN DYNAMICS,

D. E. Walling and K. J. Gregory
J Hydrol, Vol 11, No 2, pp 129-144, Aug 1970. 8 fig, 21 ref.

Descriptors: *Construction, *Urbanization, *Investigations, *Sediment yield, *Storm runoff, *Rainfall-runoff relationships, Hydrograph analysis, Soil erosion, Peak discharge.
Identifiers: Urban hydrology, Great Britain.

The magnitude of the impact of building activity upon suspended sediment concentrations may be assessed by comparing samples obtained simultaneously at different points within one catchment or comparing samples derived from two adjacent small watersheds, one of which serves as a control. In each case the suspended sediment concentrations are between 2 and 10 times, and occasionally up to 100 times, greater than the concentrations obtained from undisturbed conditions. The form of the relationships obtained demonstrates the importance of variable source areas within the catchments. To assess the yields over time, streamflow and sediment records are required. A small catchment has been instrumented for this purpose on the margin of Exeter, Devon, England. The catchment was calibrated for a period of 17 months prior to building activity by deriving multiple regression equations relating peak flow , runoff amount, and runoff percentage to precipitation characteristics at different times of the year, by evaluating unit hydrographs, by establishing suspended sediment rating curves, and by using two adjacent catchments as controls.

SECTION 2.

Overflows and Regulation Devices

090
AUTOMATIC SEWAGE REGULATOR ANNOUNCED,

Delaware Valley Ind, Vol 44, No 1, pp 27, Jan 1971.

Descriptors: *Regulated flow, *Automatic control, *Separation techniques, *Storm runoff.
Identifiers: *Sewage flow regulator, Combined sewers.

A new, automatic sewage flow regulator, developed by Neyrpic Incorporated and installed in a collector, provides for accurate flow control to the interceptor shutting off automatically all flow to the interceptor when the collector flow decreases below this preset value, the regulator opens automatically and water flows again to the interceptor thus insuring reliable and foolproof separation of sanitary flows (diverted to treatment stations) and storm waters (discharged away).

091
IN-SEWER FIXED SCREENING OF COMBINED SEWER OVERFLOWS,
Envirogenics Company, El Monte, California

EPA/WQO Contract No 14-12-180, Program No 11024FKJ, Oct 1970. 144 p, 21 fig, 11 tab, 2 ref, 9 append.

Descriptors: *Sampling, *Laboratory tests, *Sewers, *Sewerage, Storm runoff, Waste water treatment, Sewage treatment, Correlation analysis.
Identifiers: *Combined sewers, *Sewer overflows, *Fixed screens, *Solids removal.

A field sampling and analysis program, supplemented with laboratory studies, was conducted to characterize combined sewage contributions to combined sewer overflows, ascertain the removal of floatables and solid materials that could be effected by the placement of screening devices in combined sewer systems, and assess the effect of solids removal on chlorination requirements and bacterial concentrations. Statistics are presented on combined sewage bulk and screenings collected with 0.125-, 0.25-, 0.5-, and 1.0-in. aperture screens. Statistically significant correlations at the 95-% confidence level were obtained for the combined sewage bulk only between total solids and total volatile solids, between total volatile solids and total volatile suspended solids, and between total suspended solids and total volatile suspended solids. For combined sewage screenings, statistically significant correlations at the 95-% confidence level were found between total solids and total volatile solids, between BOD and COD, between BOD and hexane extractable material, and between COD and hexane extractable material. Removals of total solids, total folatile solids, biochemical oxygen demand, chemical oxygen demand,

hexane extractable material, total coliforms, fecal coliforms, and fecal streptococci resulting from placement of the screening devices into the combined sewer were marginal. Fixed screening of combined sewage with aperture sizes ranging from 0.0164 to 1.0 in. appear to have little effect on total coliform and fecal coliform densities or bacterial kills by chlorination with chlorination requirements being reduced only slightly.

092
COMBINED SEWER TEMPORARY UNDERWATER STORAGE FACILITY,
Melpar, An American-Standard Company, Falls Church, Virginia

FWQA Contract No 14-12-133, Program No 11022DPP, Oct 1970. 61 p, 16 fig, 12 tab, 2 ref, append.

Descriptors: *Pilot plants, *Underwater, *Storage, *Overflow, Laboratory tests, Costs, Investigations.
Identifiers: *Storage facilities, *Combined sewers, *Choptank River, *Cambridge, Maryland.

A pilot plant underwater storage facility was designed, constructed, operated, and evaluated as a method of temporarily storing storm overflow from the combined sewer of the Choptank Avenue drainage basin, Cambridge, Maryland. Combined sewage in excess of the sewer capacity, which would normally be discharged directly into the Choptank River, was intercepted and pumped into a normal 200,000 gallon flexible underwater storage container located 1300 feet offshore. The stored overflow was later returned from the tank at a rate which could be accommodated by the intercepting sewer and treatment plant. The facility was tested with overflow both from four naturally occurring rainfalls and using fresh water simulation. The overflow samples were analyzed in a field laboratory for the following characteristics: pH, suspended solids, volatile suspended solids, settleable solids, 5-day biochemical oxygen demand, and chemical oxygen demand. The pilot plant facility was capable of collecting 96% of the average annual overflow from the drainage basin at a cost of less than $1.85 per thousand gallons. The facility could prevent the annual discharge of 7,136 pounds BOD into the Choptank River. Underwater storage facilities could be used effectively for a number of combined sewer areas. Site selection, however, has been proven to be a critical factor. Care must be exercised to prevent public disturbance, and factors such as land use, tidal conditions, or the types of storms must also be considered.

SECTION 3.

Sewer Hydraulics

093
SURFACE WATER DRAINAGE,

L. Brassill
J Inst Munic Engrs (London), Vol 97, pp 303-310, Nov 1970. 4 fig, 4 tab.

Descriptors: *Design, *Methodology, *Sewers, *Storm runoff, Drainage Rainfall, Runoff.
Identifiers: *Storm sewers, Design research.

In this paper the design concept of sewers generally and storm sewers in particular is discussed and a review is presented of established practice and more recent research relating to this design aspect. All sewer design methods consist of the following four operations, fully detailed herein: frequency of flooding, design rate of rainfall, calculation of the rate of runoff from the rate of rainfall, and calculation of the sewer size. The author copies explore the procedure, shortcomings, and accuracy comparisons of earlier design methods, such as the rational method, the tangent method, the Coleman and Johnson system, and the Ormsby and Hart method, and more recent methods, such as the unit hydrograph method and the Road Research Laboratory Hydrograph method. It is concluded that: in schemes where sewer size larger than 24 inches are likely to be encountered the RRL hydrograph approach is the most satisfactory, otherwise the rational method gives satisfactory results; the Colebrook-White formula should be used for the solution of all hydraulic data associated with the design; and exploration concerning storm water drainage appears to have been adequately investigated for all normal design purposes.

094
REAL TIME ROUTING OF FLOOD HYDROGRAPHS IN STORM SEWERS,

Shih-Tun Su (discussion)
J Hydraulics Div, Am Soc Civil Engrs, Vol 97, No HY3, pp 464-465, Mar 1971.

Original Paper: REAL TIME ROUTING OF FLOOD HYDROGRAPHS IN STORM SEWERS,
Garth S. Harris
J Hydraulics Div, Am Soc Civil Engrs, Vol 96,
No HY6, pp 1247-1260, Jun 1970.

Descriptors: *Flood routing, Storm runoff, Hydrographs.
Identifiers: *Average-lag method, *Discussion.

Su contends that the accuracy and reliability lost by using the simplified flood routing methods should be considered in the application of such a method. A detailed listing of all the limitations

under which the progressive average lag method can be applied is advocated. A more precise measuring system or mathematical description for the three inflow hydrographs used by the author is deemed necessary to distinguish one from the other. Citing examples from the author's text, Su further contends the necessity to study other simplified routing methods in which the coefficients or parameters relate closely to the physical picture.

095
REAL TIME ROUTING OF FLOOD HYDROGRAPHS IN STORM SEWERS,

Ben Chie Yen (discussion)
J Hydraulics Div, Am Soc Civil Engrs, Vol 97, No HY2, pp 368-369, Feb 1971. 2 ref.

Original Paper: REAL TIME ROUTING OF FLOOD HYDROGRAPHS IN STORM SEWERS,
Garth S. Harris
J Hydraulics Div, Am Soc Civil Engrs, Vol 96,
No HY6, pp 1247-1260, Jun 1970.

Descriptors: *Flood routing, Storm runoff, Hydrographs, Open channel flow, Flow.
Identifiers: Storm sewers, Discussion.

For flow having mixed supercritical and subcritical modes with a critical section or a hydraulic jump occurring within the reach of the sewer, Yen contends that not only the critical section or the hydraulic jump is usually moving but also the discontinuity must occur along the characteristics thus making the method of characteristics for routing open channel flow quite complicated. Furthermore, Yen holds that the accuracy of the results obtained by using equations 19 through 22 is questionable due to the fact that sewers often do not have such a long length as in long channels with negligible backwater effect.

SECTION 4.

Sewer Systems

4a. Combined

096
FEASIBILITY OF A PERIODIC FLUSHING SYSTEM FOR COMBINED SEWER CLEANSING, FMC Corp., Santa Clara, Calif. Central Eng Labs.

Final Report - Phase I, CE45363, Aug 1970. 48 p, 11 fig, 1 tab, 23 ref. FWQA Program No 11020DN008/67.

Descriptors: Sewers, Overflow, Conveyance structures, Storm drains, Water pollution control, Costs, Flow.
Identifiers: *Combined sewers, *Storm water overflow, *Flushing systems, *Sewer flushing, Sewer cleansing.

One of the causes of pollution from storm water overflow of combined sewers is the deposition of pollutional solids during the dry weather flow followed by pick up of the pollutional material during storm flow when the flow is bypassed. As a solution to this problem, it has been proposed that a flushing system be used to periodically cleanse the sewers during the dry weather and convey the solids to the treatment plant. Under Phase I a study was made of sewer flushing practices, application requirements, and hydraulic theory. Investigation was also made of sampling methods and equipment; flushing test equipment was designed for use in Phase II, and the cost of Phase II was estimated. It was confirmed that additional detailed information is needed to apply a periodic flushing system to actual combined sewers. It was also concluded that the existing information on sewer flushing indicated a good possibility that a periodic flushing system would be feasible for reducing pollution from combined sewer storm water overflow. The detailed information needed to apply a sewer flushing system must be determined by a large number of controlled experiments of flushing effectiveness. The design of flushing evaluation equipment for use in Phase II has been carried to the point where a cost estimate can be made for construction of the equipment. A description of the design and the cost estimates are included in this report.

4b. Sanitary

TUNNELING SYSTEM PULLS INSTEAD OF PUSHING LARGE DIAMETER STEEL PIPE,

Jiro Wakabayashi
Construct Methods Equip, Vol 53, No 2, pp 96-100, Mar 1971.

Descriptors: *Installation, *Construction equipment, *Tunneling, *Methodology, *Steel pipes, Data collections.
Identifiers: *Sanitary sewers, *Japan.

A Japanese contractor has successfully used a U.S.-developed jacking system to pull some 200 feet of 96-inch diameter steel casing for a sewer line through the saturated subsoil of a creek without first cofferdamming, dewatering, or grouting the site. The Japan Development & Construction Company installed a 282-ft-stretch of sanitary sewer under an existing creek that runs through suburban Yokohama without disrupting its use as an open sewer for the surrounding houses. The pulling system used for installing the pipe consists of a circular steel jacking frame; 48, 15-ton hydraulic jacks mounted equidistant around the frame; and high strength pulling cables running from the jacks to points around the circumference of the pipe's cutting edge. Details of the construction procedure are given. A one-shift operation was worked on the subaqueous tunneling job while a daily compilation of data from a gage recording the thrust required by the system as the casing was pulled through the soil was delivered to the engineering department for analysis and evaluation as well as planning the next day's operation.

4c. Storm

COVENTRY CITY CORPORATION SEWERAGE AND SEWAGE TREATMENT,

Peter Beaumont
Surveyor, Vol 137, No 4100, pp 47-48, Jan 8, 1971.

Descriptors: *Overflow, *Storm runoff, *Treatment facilities, *Sewers, Construction, Storage tanks, Sewage treatment.
Identifiers: *Great Britain.

A $36 million program, begun in the 1950's, to replace the city's trunk sewers and major branch sewers is designed to end pollution caused from overflows in overloaded sewers during times of storm runoff. Storm water balancing stations are being provided to hold excess flow until it can be pumped back to the sewer when the storm is over. The extensions undertaken at the Finham sewage treatment works are discussed and emphasized are the workings of the treatment plants.

SECTION 5.

Storm water - Quality, Quantity, and Pollution

5a. Caused from combined overflows

099
QUANTITY AND QUALITY RELATIONSHIPS FOR COMBINED SEWER OVERFLOWS,

A. O. Friedland, T. G. Shea, and H. F. Ludwig
Fifth International Water Pollution Research Conference, San Francisco, Jul 26-Aug 1, 1970. Preprint Paper I-1. 16 p, 5 fig, 5 tab, 2 ref.

Descriptors: *Flow, *Hydrology, *Mathematical models, *Hydrographs, *Storm runoff, Waste water treatment, Water pollution, Water quality.
Identifiers: Combined sewage.

The results of a one-year program of wet and dry weather monitoring of five combined sewer systems and one storm sewer system in San Francisco, are presented. The time concentration profiles of combined sewage constituents follow a definite three-phase variation initially having characteristics of raw sewage increasing in the second phase to 125 to 200% of the characteristics of raw sewage, and receding in the third phase to levels of 10 to 25% of the characteristics of raw sewage. No correlation was found between the mass emission of constituents due to storm and the antecedent dry period, land use character, or rainfall intensity. Storm runoff emission equations for COD, total suspended solids, total nitrogen, and ortho-phosphate are included. Hexane extractable material and floatables can be used in conjunction with dry weather flow, waste load coefficient, a rainfall history, basin acreage, and population to estimate wastewater loads. Weather diversions contain twice the total nitrogen and orth-phosphate phosphorus, 50 to 60% more total nitrogen and COD, 20% more floatables, and 10% more total suspended solids than the storm runoff fraction of the diversion alone would contain. The nitrogen and phosphorus emissions from secondary forms are significantly greater than emissions of these constituents from combined or storm sewage flows on an annual basis.

5b. Caused from storm runoff

100
VARIATION OF URBAN RUNOFF WITH DURATION AND INTENSITY OF STORMS,

Robert C. Brownlee, T. Al Austin, and Dan M. Wells
Texas Tech University Water Resources Center Interim Rep No WRC-70-3, Sep 1970. 68 p, 12 fig, 30 tab, 10 ref.

Descriptors: *Storm runoff, *Water pollution sources, Urbanization, Sewage treatment, Statistics, Sewage disposal, Data collections, Hydrologic data.
Identifiers: Urban runoff, Combined sewers.

A great many cities transport raw domestic sewage to treatment facilities in the same sewer systems used to carry storm runoff from the streets. The storm runoff carried by these combined sewers, during even moderate rainstorms, can greatly exceed the capacity of municipal sewage treatment plants. This study was undertaken to determine the concentrations of pollutants carried by the storm runoff from a small residential watershed, and to consider the variations of pollutant concentrations with the duration of runoff. Surface runoff from rainstorms on the small residential watersheds contains pollutant concentrations which vary in average and extreme values from storm to storm. Average total dissolved solids and nitrates as well as the average pH value of storm runoff are within the USPHS standards for drinking water, while solids concentrations and total alkalinity concentrations are in the range of those found in raw sewage influent. Average BOD concentration of the samples tested is approximately the same as that of secondary sewage treatment effluent. Regression and correlation analyses indicate a definite reduction in constituent concentrations with duration of runoff. Rainfall intensities, antecedent moisture conditions, storm movements, and other parameters also influence this relationship.

101
QUALITY OF STORM WATER DRAINAGE FROM URBAN LAND AREAS IN NORTH CAROLINA,

Edward H. Bryan
North Carolina Water Resources Research Institute Rep No 37, Jun 1970. 43 p.

Descriptors: *North Carolina, *Water quality, Storm runoff, Surface runoff, Water quality control, Drainage, Urbanization, Surface drainage.
Identifiers: *Storm water drainage, Urban runoff.

The objective of this project was to determine the quality characteristics of storm water drainage from an urban land drainage basin in North Carolina as influenced by the nature of land use on the basin.

The purpose of this study was to determine quantitative relationships between different land-use patterns and consequent differences in the water quality. The drainage basin selected has an area of 1.67 square miles and is in the upper portion of the Cape River Basin of North Carolina. Residential, commercial, and industrial activities on the selected basin are representative of the urban land-use pattern in North Carolina cities and towns. During the first year a gaging and sampling station was installed on the outlet of the major basin. In the second year, the major basin was divided into a number of subsidiary basins to characterize the quality of water draining from each sub-basin and attempt correlation of its qualities with land use. Urban storm water was found to be a significant source of pollutional constituents to receiving streams. With respect to BOD, the total weight contribution by storm water from this basin was estimated to equal that of its sanitary wastewater effluent from secondary treatment. The contribution of total organic matter as measured by chemical oxygen demand in its storm water was greater than that attributable to discharge of raw sanitary wastewater from a strictly residential, average urban area. The total solids contribution by urban storm water was substantially larger than would be expected from average raw domestic wastewater. The contribution of phosphate from this urban basin was nominal for urban storm water in comparison with that of domestic wastewater.

102
EXTENT OF POLLUTION BY STORMWATER OVERFLOWS AND MEASURES FOR ITS CONTROL,

K. Inaba
Fifth International Water Pollution Research Conference, San Francisco, Jul 26-Aug 1, 1970. Preprint Paper HA-8. 7 p, 4 fig, 1 ref.

Descriptors: *Water pollution, *Storm runoff, *Sewage, *Hydrology, *Hydrographs, Ponds, Waste water treatment, Mathematical models, Sewerage.
Identifiers: *Combined sewage, *Japan.

A study of the quantity and quality of storm sewage from a combined sewerage system in Tokyo metropolis was conducted in the period 1966-1967. Three interconnected aspects of the study are discussed: 1) the hourly variation of storm sewage and storm water quality and quantity in urban areas, 2) some considerations on the method of estimating these factors, and 3) the control of storm sewage flow and quality. It is important to estimate the hourly variation of storm sewage or storm water quality as a function of rains at all intensities so that accurate measures can be taken for control based on a sound mathematical model. Several possibilities are investigated and it is concluded that in a combined system it is most economical and reasonable to divide the total pollution in storm sewage between the outfall sewer to the treatment works, a storage tank, and storm sewage outflows.

103
A SYSTEMS STUDY OF STORM RUNOFF PROBLEMS IN A NEW TOWN,

Charles W. Mallory and John J. Boland
Water Resources Bulletin, Vol 6, No 6, pp 980-989, Nov-Dec 1970.
4 tab, 7 ref.

Descriptors: *Storm runoff, *Urbanization, *Systems analysis, *Simulation analysis, Mathematical models, Computer models, Water pollution control, Water supply, Optimization, Water reuse, Sediment control.
Identifiers: *Columbia, Maryland, *Urban hydrology.

A system study was conducted on the use of a large number of small reservoirs dispersed throughout an urban community as a means of storm water pollution control. The study was based on an area within the 'new city' of Columbia, Maryland. Water collected and stored in the reservoirs is treated for release or use in meeting subpotable and potable water demands in the community. Design and performance criteria were developed for such a system. A simulation model and a computerized evaluation technique were used to select the optimal locations and system configurations. The results of this study indicated that such a system would be less expensive than a conventional engineering approach to storm water pollution control. Further, the benefits derived from use of the storm water as a water supply can offset a portion of the cost of pollution control. Several secondary benefits also result from this concept including erosion and sediment control, storm flow dampening, and recreational facilities. A program is now underway to demonstrate this concept in Columbia, Maryland.

104
URBAN SOURCES OF NITRATE,

James M. Symons
Illinois University Urbana Bulletin, Vol 68, No 2, pp 78-85, Aug 5, 1970. From 12th Sanitary Engineering Conference Proceedings on NITRATE AND WATER SUPPLY: SOURCE AND CONTROL, Urbana, Illinois, Feb 11-12, 1970.

Descriptors: *Industrial wastes, *Urbanization, *Storm runoff, *Sewage, *Water supply, *Nitrates.
Identifiers: *Nitrogen sources.

The urban sources of nitrate nitrogen are dealt with, and data on nitrite, nitrogen, ammonia, and organic nitrogen are included in the study since they can be partially or totally biologically oxidized to the nitrate form. The sources of urban nitrogen include human wastes from individual and central sewage systems, runoff from separate and combined storm water systems, rainfall, and industrial wastes. These sources are discussed in terms of the quantities and concentrations of readily biologically oxidizable

nitrogen they contribute, and the degree of dilution each has to undergo in meeting with United States Public Health Standards requirements for nitrate nitrogen in drinking water supplies.

SECTION 6.

Surveys, Policies, and Reports

105
STORMWATER QUALITY,

Public Works, Vol 102, No 1, pp 99, Jan 1971.

Descriptors: *Surveys, *Investigations, *Storm runoff, *Water quality, Drainage systems, Urbanization, North Carolina, Sampling, Water pollution, Water pollution sources, Flow rates.
Identifiers: *Parametrics.

This is a synopsis of a report conducted by E. H. Bryan at the Water Resources Research Institute of the University of North Carolina which investigated the "Quality of Stormwater Drainage from Urban Land Areas in North Carolina". This project was undertaken to evaluate the quality characteristics of storm water runoff from a 1.67 square mile drainage basin within the city of Durham, North Carolina. Parameters selected for routine examination included total solids, volatile total solids, BOD, COD, chloride, soluble phosphate, total phosphate, fecal coliform counts, and lead. Flows were sampled from approximately 30 storms among 70 which occurred over a period of fourteen months. Results obtained indicated that: discharged BOD is estimated at 0.23 pound/acre/day; COD measures at 2.85 pounds/acre/day; total solids contribution is substantially larger than expected from raw domestic sewage; pollutants are discharged in slugs during and immediately following storms; pesticide analyses indicate a total concentration of 1.16 ppb; and, lead concentration of the runoff averaged 1190 lbs/sq. mile for an annual yield.

106
THE ENVIRONMENTAL DECADE (ACTION PROPOSALS FOR THE 1970's): From the Conservation and Natural Resources Subcommittee, Committee on Government Operations

Hearings before the Committee on Government Operations, 91 Cong, 2d Sess, Feb 2-6, Mar 13, and Apr 3, 1970. 367 p.

Descriptors: *Environmental engineering, *Separation techniques, *Sewers, *Waste treatment, *Treatment facilities, *Pollution abatement, *Water pollution control, *Standards, *Waste disposal, *Soil erosion.
Identifiers: *Proposals, *Funding, *Air pollution control, *Environmental control.

Congressional testimony is reported on proposals for the 'Environmental Decade of the 1970's'. The proposals include adequate funding for waste treatment plants, separation of storm and sanitary sewers, development of desalinization and recycling, the prevention of waste

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by evaporation and other causes, elimination of sources of pollution, preservation of wetlands and estuaries, development of pollution-free automotive engines as alternatives to present internal combustion engines, standards for industrial and power plants in elimination of polluting discharges, elimination of agricultural soil erosion and siltation from highway construction and suburban development, control of chemical pollution from the use of fertilizers, standards for regional and national planning, and strict controls for solid waste disposal.

107
CONCEPTUAL ENGINEERING REPORT: KINGMAN LAKE PROJECT,
Roy F. Weston, Inc., West Chester, Pennsylvania

FWQA Contract No 14-12-829, Program No 11023FIX, Aug 1970. 149 p, 7 fig, 23 tab, 25 ref, 5 append.

Descriptors: *Filtration, *Flow measurement, *Rainfall-runoff relationships, *Recreation facilities, Rainfall intensity, Depth-area-duration analysis, Storm runoff, Overflow, Organic loading, Pollutants, Standards, Waste water treatment, Activated carbon, Sewers, Tunnel design, Technical feasibility, Annual costs, Capital costs, Cost-benefit analysis, Water storage, Water reuse, District of Columbia, Pollution abatement.
Identifiers: *Combined sewers.

This conceptual engineering study concerns the reclamation of combined sewer overflows and utilization of the reclaimed waters in a major water-oriented recreational facility for the District of Columbia. The investigation encompasses a comprehensive solution of environmental problems by proposing multi-use objectives and facilities. Principal objectives of the project include: 1) evaluation of rainfall-runoff relationships for sizing of storage and treatment plant capacities; 2) confirmation of treatment feasibility using filtration and an activated carbon process; and 3) development of sufficient data for preliminary design purposes. Laboratory studies not only demonstrated process feasibility, but showed the need for including flocculation and sedimentation for removal of minute particles, together with chlorine and iodine addition for maximum disinfection. The recommended storage/treatment plan provides for a 175 million gallon storage basin, a 50 million-gallon/day reclamation facility, and two 46-acre swimming and boating lakes. Cost effectiveness (cost/benefit ratio) of the project, as envisioned, has been indicated to be 1.6 at an estimated total project cost of $45,200,000, and an estimated annual operating cost of $1,777,000. Implementation of the proposed plan would not only provide a least-cost alternative over single-purpose projects to attain identical objectives, but would also reduce the annual pollution now discharged by the Northeast Boundary Trunk Sewer by approximately 99 percent.

108
IMPACT-TYPE ENERGY DISSIPATOR FOR STORM-DRAINAGE OUTFALLS STILLING WELL DESIGN,
Army Engineer Waterways Experiment Station, Vicksburg, Miss.

Technical Rep, No 2-620, Mar 1963. 66 p, 9 tab, 37 plates.

Descriptors: *Drainage, *Storms, *Underground structures, *Erosion, Pipes, Design, Flow, Stilling basins.
Identifiers: *Energy dissipator.

An impact-type energy dissipator consisting of a vertical section of circular pipe affixed to the outlet end of a storm drainage outfall, termed a stilling well, was studied in the laboratory to determine the energy loss coefficient and the effects of the geometrical components of such a structure. The results were generalized and given in terms of dimensionless parameters. Investigations were conducted with a 0.99-ft-diameter model stilling well which had a 2-ft-diameter collar attached to the top to simulate a broad-crested circular weir, and incoming pipes with diameters of 0.33, 0.40, and 0.60 ft on slopes of 1 on 1, 1 on 2.2, and 1 on 4. There is an optimum depth of the stilling well below the invert of the incoming pipe, dependent on the slope of the incoming pipe. Limited tests indicated that there is also an optimum height of the well above the pipe invert for each given set of conditions. In regard to energy dissipation, test results show that the smaller the ratio of the diameter of the incoming pipe to that of the stilling well and the flatter the slope of the incoming pipe, the greater the value of the energy loss coefficient. The energy loss coefficient is less for full pipe flow than for partial pipe flow. Discharge coefficients for a circular stilling well were determined for both partial and full pipe inflows and free outflow conditions, and empirical equations were developed.

109
FLOOD PLAIN INFORMATION, CITY OF ALEXANDRIA AND ARLINGTON COUNTY, VIRGINIA, FOURMILE RUN,
Corps of Engrs, Baltimore, Maryland

Report, Oct 1968. 38 p, 11 fig, 7 tab.

Descriptors: *Flood forecasting, *Flood plains, *Flood damage, *Storm runoff, *Urbanization, Planning, Runoff, Flood control, Drainage, Regional flood.
Identifiers: *Fourmile Run, Virginia, *Arlington County, Virginia, *Alexandria, Virginia, *Arlandria, Virginia.

Flooding was studied on the lower 3 miles of Fourmile Run, a floodway draining 18.5 square miles that flows 9 miles through Arlington County, along the northern boundary of Alexandria, Virginia, and discharges into the Potomac River downstream of Washington National Airport. During the largest flood of record, in August 1963, damage to business

properties in a four-block stretch of Arlandria was estimated at more than one million dollars. Two significant phases are covered of the Fourmile Run flood problem: (1) the largest known floods, and (2) probable future floods. Estimates are made of the maximum velocities, discharge rates, and flood depths that would result from a flood having a 100 year average recurrence interval, and from the maximum probable flood that could ever be anticipated in the area. This latter flood would top the flood depth of record by 10.3 feet on Mount Vernon Avenue in Arlandria, and discharge 25,000 cfs at its peak. The report is intended to provide the basis for further study and planning by Arlington County and Alexandria to develop solutions. The report contains maps, profiles and cross-sections that indicate the extent of future flooding anticipated. These can be used to guide and plan land developments, and to formulate zoning ordinances and subdivision regulations. They can also be used in planning flood protection works.

110
REPORT ON FOURMILE RUN FLOODING, ALEXANDRIA, VIRGINIA,
Greeley and Hansen, Chicago, Illinois

Report to City of Alexandria, Virginia, Apr 1968. 66 p, 14 fig, 5 tab.

Descriptors: *Flood protection, *Flood control, *Storm runoff, *Urbanization, *Drainage engineering, Construction costs, Runoff, Planning.
Identifiers: *Fourmile Run, Virginia, *Arlington County, Virginia, *Alexandria, Virginia, *Arlandria, Virginia.

General design criteria are developed along with a basis of design for the construction of engineering works to protect property from flooding along Fourmile Run between the stream's outlet to the Potomac River and the Shirley Highway. Fourmile Run carries storm water runoff from an 18.5 square mile drainage area in Arlington County. Extensive damage to commercial and residential properties results from flash floods, particularly in the Arlandria area at the North boundary of the City of Alexandria. The data obtained on the maximum flood of record, August 20, 1963, were considered in the study. The recommended basis of design is to provide for a minimum discharge of 20,000 cfs, but, preferably, 24,000 cfs. The construction costs for the latter are estimated at $9,437,000, based on 1968 unit costs. The project would entail: the removal and construction of new culverts, bridges and a railroad trestle which constitute streamflow bottlenecks; provision of storage in the main stem by channel improvement and levee construction; off-channel detention storage on City-owned property located in the flood zone; and miscellaneous provisions, including possible removal of buildings from the flood plain. The Fourmile Run flash flooding problem is a prime example of similar situations in various parts of the country.

111
MERCER COUNTY, NEW JERSEY, COMPREHENSIVE PLAN: ANALYSIS OF WATER SUPPLY AND SEWERAGE FACILITIES OF MERCER COUNTY,
Mercer County Planning Board, Trenton, New Jersey

Final Rep, No 7, Nov 1969. 41 p, 7 tab, 2 map, 19 ref.

Descriptors: *Sewers, *Water resources, *Waste water (pollution), *Waste treatment, *Treatment facilities.
Identifiers: *Mercer County, New Jersey, *Regional planning.

Approximately 266,000 of Mercer County's 300,000 population is supplied with water from public or private water sources. The remainder receives its water from individual private wells. The source of water for 75 percent of the County is the Delaware River and the Water is supplied by the city of Trenton Water Company. The analysis indicates that the County has adequate water resources to handle expected future development. Most of Mercer County's population is serviced by modern wastewater collection and treatment facilities. For the remainder of the County, preliminary engineering reports and feasibility studies are being prepared by municipal officials and study groups to indicate how these areas can be serviced.

112
MERCER COUNTY, NEW JERSEY, COMPREHENSIVE PLAN: STORM WATER RUNOFF AND DRAINAGE FACILITIES,
Mercer County Planning Board, Trenton, New Jersey

Final Report, Sep 1969. 30 p, 5 tab, 10 ref.

Descriptors: *New Jersey, *Drainage, *Runoff, Rainfall, Culverts, Surveys.
Identifiers: *Regional planning, *Storm water, *Mercer County , New Jersey.

Major problems occur in developing areas when open land which formerly absorbed rain water becomes covered with structures and asphalt. The county has a major responsibility in ensuring that, as land becomes developed and storm water runoffs increase, facilities guiding flows under county roads remain adequate to handle the increased water flow. The report analyzes each of the drainage areas adjacent to existing major county bridges or culverts to determine whether they will be adequate to handle increased flows when the drainage areas develop as presently zoned.

113
STORM DRAINAGE IN THE TOLEDO REGIONAL AREA,
Toledo Regional Area Plan for Action, Ohio

Regional Report 9.3, Office of the Lucas County Engineer, Sep 1969.
118 p.

Descriptors: *Storm drains, *Drainage systems, Urbanization, Floods, Sanitary engineering, Standards.
Identifiers: *Storm sewers, *Toledo, Ohio, Combined sewers.

The report is an inventory and analysis of existing storm drainage systems. The collected information provides a basis for solving immediate drainage problems, guiding new development to those areas amenable to good drainage, and planning for future drainage improvements. Subject areas covered by the study include: planning and financing of storm drainage facilities, general standards for storm drainage systems, mapping for watershed areas, and computation of storm water runoff and water surface elevations. Two important problem areas examined are flooding and combined sewers.

114
STORM DRAINAGE FACILITIES, UNION COUNTY, NEW JERSEY,
Union County Planning Board, New Jersey

May 1970. Various pagings.

Descriptors: *Management, *Planning, New Jersey, Floods, Drainage, Storms, Structures, Rainfall, Design, Roads, Maps.
Identifiers: *Storm sewers, *Union County, New Jersey.

The report presents an inventory and analysis of the storm drainage facilities of Union County, New Jersey. Points of analysis were generally selected where streams cross major County thoroughfares. The tributary areas to each of these points were determined. Estimates of minimum design flows were prepared. These suggested minimum design flows were then used to determine the adequacy of the existing drainage facility at the point of analysis. The second stage of this report will analyze tidal influence upon storm drainage facilities and present a recommended plan of improvements.

115
RECOMMENDED REGIONAL PLAN FOR SEWERAGE, WATER SUPPLY AND STORM DRAINAGE,
Valley Regional Planning Agency, Ansonia, Conn.

HUD Project Conn. P-103, Feb 1970. 60 p, append.

Descriptors: *Urbanization, *Planning, *Connecticut, *Sanitary engineering, Sewage, Drainage, Floods, Water supply.
Identifiers: *Storm sewers.

The report presents the recommended regional plan and program for sewerage, water supply, and storm drainage for the 58 square mile Valley Planning Region, comprising Ansonia, Derby, Seymour, and Shelton, Connecticut.

116
STORM DRAINAGE: INVENTORY AND ANALYSIS OF MAJOR EXISTING AND PLANNED FACILITIES. VOLUME V: STORM DRAINAGE,
Valley Regional Planning Agency, Ansonia, Conn.

HUD Project Conn. P-103, Feb 1970. 18 p.

Descriptors: *Urbanization, *Planning, *Connecticut, *Drainage, *Sewers, Floods, Sewage, Sanitary engineering.
Identifiers: *Storm sewers.

This is the fifth of a five-volume report that is being utilized as part of the basis for an areawide water/sewer plan and program for the Valley Region. This volume includes an inventory and evaluation of the major existing and planned facilities. The inventory includes a delineation of present areas served by storm sewers and areas requiring flood protection. (See abstract number 115.)

117
TECHNICAL COMMITTEE ON STORM OVERFLOWS AND THE DISPOSAL OF STORM SEWAGE: FINAL REPORT,
Ministry of Housing and Local Government, England

1970. 76 p, 2 append.

Descriptors: *Publications, *Storm runoff, *Sewage disposal, *Sewers, *Investigations, Surveys, On-site investigations, Structures, Model studies.
Identifiers: *Great Britain, *Storm overflows.

This is the final report of the Technical Committee on Storm Overflows and the Disposal of Storm Sewage appointed on May 20, 1955 whose purpose it was to "study and report upon practices relating to storm overflows on sewers and the disposal of storm water and to make recommendations". An extensive program of experimental and special studies have been conducted and are reported herein under individual chapter headings. Chapters are abstracted separately and follow below.

118
TECHNICAL COMMITTEE ON STORM OVERFLOWS AND THE DISPOSAL OF STORM SEWAGE: CHAPTER 1. INTRODUCTION,
Ministry of Housing and Local Government, England

pp 1-4, 1970. 2 ref.

Descriptors: *Publications, *Investigations, Flow rates, Model studies, On-site investigations, Storm runoff, Overflow.
Identifiers: *Great Britain, *Historical review, Storm overflows, Storm tanks.

The historical evolution of the sewerage system in England and Wales is outlined. Until 1955 requirements for design practices of sewer systems, treatment measures, and the construction of storm overflows were based on 1898 report conclusions. Since 1955, investigations have been initiated by the Technical Committee in the following areas: 1) a survey of storm overflows in 52 local authority areas to obtain information about the numbers and types of overflows in existence and the local circumstances in which they operated; 2) an investigation of the rate of flow and composition of storm sewage in three drainage areas; 3) experiments on small-scale models of different types of overflows to compare their performance and assess the value of storage under the time-varying flow of storm conditions; 4) field-scale experiments on different types of overflows, to test their hydraulic efficiency and also their efficiency in limiting the amount of pollution discharged by the overflows; and 5) an investigation of the performance of storm tanks. (See abstract number 117.)

119
TECHNICAL COMMITTEE ON STORM OVERFLOWS AND THE DISPOSAL OF STORM SEWAGE: CHAPTER 2. EXTENT OF THE PROBLEM,
Ministry of Housing and Local Government, England

pp 5-9, 1970. 2 fig, 2 tab, 1 ref.

Descriptors: *Publications, *Surveys, Surface waters, Water pollution sources.
Identifiers: *Great Britain, *Storm overflows.

Storm overflows occur in all combined and partially-separated sewer systems. Only 8% of the authorities covered (226 works) by the survey have completely separate sewerage systems. Pollutional problems arise from some surface runoff yet it is recommended that surface water runoff be connected to sewers only when runoff is heavily polluted. It is further recommended that re-sewering be done on a separate system basis as the need and funds arise. A storm overflow questionnaire was completed by authorities representing 3.6% of all local areas serving 8.2% of the total population on main drainage. Of the 849 overflows surveyed, 317 were considered unsatisfactory for the following various reasons: stranding of solids in vicinity of watercourse, effect on biology, operation in dry weather, too frequent operation

in wet weather, combined influence with neighboring overflows, and deposits of sludge in the watercourse. (See abstract number 117.)

120
TECHNICAL COMMITTEE ON STORM OVERFLOWS AND THE DISPOSAL OF STORM SEWAGE: CHAPTER 3. FIELD STUDIES ON FLOW AND COMPOSITION OF STORM SEWAGE,
Ministry of Housing and Local Government, England

pp 10-35, 1970. 12 fig, 15 tab, 3 ref.

Descriptors: *Publications, *On-site investigations, *Rainfall, *Storm runoff, *Sewage, Flow measurement, Overflow, Flow rates.
Identifiers: *Great Britain, *Sewage composition.

A program of field studies was undertaken by the Water Pollution Research Laboratory at Northampton, Brighouse, and Bradford in order to collect information on the flow and composition of storm sewage. At each site records of rainfall and the composition of storm sewage were maintained and the composition of dry-weather sewage was measured on a number of occasions during the following test periods: February 1960 to January 1962 at Northampton, from November 1958 to December 1961 at Brighouse, and from February 1961 to January 1964 at Bradford. Results from flow measurements at Northampton and Brighouse may be useful in predicting the annual duration and volume of discharge from hydraulically efficient overflows in other areas. Further, it was found that storm sewage was weakest during the night, although there was less diurnal variation than observed in the dry-weather sewage; its strength decreased with time during storms, and to some extent depended upon the flow. Although there were wide variations in the composition of storm sewage from site to site and from time to time, a rough estimate of the average strength of storm sewage found in these areas is 400 mg/l suspended solids, 40 mg/l permanganate value, 80 mg/l BOD, and 4 mg/l ammoniacal nitrogen. (See abstract number 117.)

121
TECHNICAL COMMITTEE ON STORM OVERFLOWS AND THE DISPOSAL OF STORM SEWAGE: CHAPTER 4. LABORATORY EXPERIMENTS OF MODELS OF STORM OVERFLOWS,
Ministry of Housing and Local Government, England

pp 36-42, 1970. 4 fig, 2 tab, 2 ref.

Descriptors: *Publications, *Laboratory tests, *Model studies, Analysis.
Identifiers: *Great Britain, *Storm overflows, *Comparative performance.

The main purpose of the laboratory experiments was to compare the effectiveness of four types of overflows with non-steady polluting

discharges and to assess the extent to which storage of a first flush of heavily polluting storm sewage might be beneficial. The overflows studied were a low side-weir, a stilling pond, a vortex with spill over a central ring weir, and an overflow with storage beyond high side-weirs. A summary of performance with polluting material according to A (gradient 1 to 500) and B (gradient 1 to 100) shows that: low side-weir -- (A) worst of the four with grit and coarse solids yet good retention of floating solids with scumboards, and (B) best retention of floating solids with scum-boards and moderate performance with dissolved pollution, coarse solids, and grit; stilling pond -- (A) best of the four with coarse solids and grit and good retention of floating solids with scum-boards, and (B) moderate performance with all pollutants; vortex with central weir -- (A) moderate other than poor retention of floating solids, and (B) worst of the four with dissolved pollution and similar to the spilling pond for others; and storage type -- (A) best of the four with dissolved pollution and best retention of floating solids with or without scum-boards, and (B) moderately good with dissolved pollution yet best of the four with coarse solids and best retention of floating solids without scum-boards. (See abstract number 117.)

122
TECHNICAL COMMITTEE ON STORM OVERFLOWS AND THE DISPOSAL OF STORM SEWAGE: CHAPTER 5. FIELD-SCALE EXPERIMENTS ON STORM OVERFLOWS, Ministry of Housing and Local Government, England

pp 43-50, 1970. 3 fig, 1 tab, 2 plate, 2 ref.

Descriptors: *Publications, *On-site investigations.
Identifiers: *Great Britain, *Storm overflows, *Comparative performance.

This chapter describes experiments involving the steady flow of crude sewage at various rates in storm overflow structures at the East Hyde Sewage Treatment Works of the Luton Corporation. The following results were determined: 1) the low side-weir was shown to be inefficient as a device for accurate hydraulic separation, spilling prematurely and lacking control at high flows; 2) the stilling pond with orifice control was satisfactory in its control of flow to treatment, yet currents set up in the fan-shaped chamber were not conducive to efficient settlement of solids; 3) the vortex with orifice control was reasonably satisfactory in its control of flow to treatment, and its performance in retaining gross solids was poor except at high flows; and 4) the high-weir with orifice control was comparable to the stilling pond in hydraulic performance, and had the best performance of all the overflows tested (with scum-boards) in retaining gross solids and faeces. A comparison of tests on laboratory scale and on field scale is included. (See abstract number 117.)

123
TECHNICAL COMMITTEE ON STORM OVERFLOWS AND THE DISPOSAL OF STORM SEWAGE: CHAPTER 6. THE SETTING OF STORM OVERFLOWS,
Ministry of Housing and Local Government, England

pp 51-58, 1970. 2 ref.

Descriptors: *Publications, *Mathematical studies.
Identifiers: *Great Britain, *Storm overflows, *Overflow setting.

Various formulae have been considered which attempt to achieve the aims of raising the average setting and making appropriate allowance for water usage variations, infiltration, and industrial effluents. None of these formulae can possibly be precise in the sense that its application could control the amount or quality of overflow accurately to predetermined levels. Furthermore, none is likely to be fully applicable to areas with very long times of concentration. Favored by the Committee is Formula A which is the simplest and whose scope is restricted to achieving a modest improvement on present practice and to making a more appropriate allowance for variations in water usage, infiltration and industrial flow. Formula A is: setting (Q) = DWF + 300 P + 2E g.p.d. where DWF is the dry-weather flow in gallons/day; P is the population of these areas; and, E is the volume of industrial effluent in gallons discharged in a 24-hour period. (See abstract number 117.)

124
TECHNICAL COMMITTEE ON STORM OVERFLOWS AND THE DISPOSAL OF STORM SEWAGE: CHAPTER 7. STORM OVERFLOW STRUCTURES,
Ministry of Housing and Local Government, England

pp 59-62, 1970. 1 tab.

Descriptors: *Publications, *Design criteria, *Structural analysis, *Structural engineering, *Structures.
Identifiers: *Great Britain, *Storm overflows.

In the design of storm overflow structures, the following aspects should be considered and hopefully achieved: 1) it should not come into operation until the prescribed flow is being passed to treatment; 2) the flow to treatment should not increase significantly as the amount of overflowed storm sewage increases; 3) the maximum amount of polluting material should be passed to treatment; 4) the design should avoid any complication likely to lead to unreliable performance; 5) the chamber should be so designed as to minimize turbulence and risk blockage, it should be self-cleansing and require the minimum of attendance and maintenance. The two most significant factors affecting the design of overflow structures are hydraulic limitations and the handling of the wide variety of solid matter liable to be present in sewage. These aspects are discussed in relation to overflows in current use and overflows with downstream storage. (See abstract number 117.)

125
TECHNICAL COMMITTEE ON STORM OVERFLOWS AND THE DISPOSAL OF STORM SEWAGE: CHAPTER 8. STORM TANKS,
Ministry of Housing and Local Government, England

pp 63-68, 1970. 8 tab.

Descriptors: *Publications, *On-site investigations, *Analysis, Operations, Design criteria.
Identifiers: *Great Britain, *Storm tanks.

This chapter describes the main investigations in a study of storm tanks conducted at the Northern Sewage Works of the Borough of Royal Tunbridge Wells and at the Blithe Valley Sewage Works of the City of Stoke-on-Trent. The objective was to obtain records for most of the storm occurrences over a period of about two years. Among the information recorded for each storm was the time when flow into the tanks started and stopped, the state of the tanks at commencement of inflow, the time when flow out of the tanks to the stream started and stopped, and the contents of any tanks partly filled at the end of the storm. Results of the investigations were tabulated according to sewage strength, BOD sampling ranges, flow rates, purification, storage capacity, polluting load discharge, and retention periods. Design considerations and storm tank operation are included. (See abstract number 117.)

126
TECHNICAL COMMITTEE ON STORM OVERFLOWS AND THE DISPOSAL OF STORM SEWAGE: CHAPTER 9. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS,
Ministry of Housing and Local Government, England

pp 69-73, 1970.

Descriptors: *Publications.
Identifiers: *Storm overflows, *Summary, Great Britain.

Each chapter of the Final Report is summarized briefly. It is concluded by the Committee that there are generally too many storm overflows and that sewerage authorities could examine their systems with a view to using overflows and sewer capacity to the optimum extent. Other conclusions and recommendations which are described in detail in individual chapters are reiterated. The Committee recommends the following areas for future research: 1) the effect of intermittent discharges of storm sewage on streams; 2) storage and control of gross solids discharge; and 3) information on storm tank operation. (See abstract number 117.)

127
THE OPTIMIZATION OF STORM HOLDING TANKS: A PROBLEM OF WATER POLLUTION CONTROL,

Charles Albert Kohlhaas
Stanford University Thesis, 1970. 337 p.

Descriptors: *Water pollution, *Water pollution control, *Water pollution sources, *Storm runoff, *Reviews, *Overflow, *Infiltration, *Sewers, *Storage tanks, Costs, Water quality, Water quality control, Hydrology, Environmental effects, Control systems, Standards, Mathematical models, Biochemical oxygen demand.
Identifiers: *Combined sewers, *Storm sewage, *Effluent tax, Treatment methods, Stream standards.

A literature review of the hydrology, effect on the environment, and control technology of combined sewer overflows and overflows from sewers subject to heavy infiltration is made. An analysis of water pollution externalities and remedies for dealing with them, including the use of the effluent tax, is given. The relationship between the pollution caused by storm-sewage overflows and competing urban needs is investigated. Two mathematical programs for optimizing control facilities for storm-sewage overflows are defined wherein one achieves economic efficiency by means of the effluent tax, and the other incorporates water quality goals by means of stream standards. The stream standards program is applied to a practical problem of storm-sewage overflow in East San Francisco Bay, California. Water quality regulations for controlling overflows are formulated. Treatment processes based on the use of holding tanks are defined. The effect of a holding tank on input discharge, BOD, and coliform concentrations is described by means of equations. The mathematical program is solved as a separable non-linear program. The cost of meeting different levels of water quality is investigated by changing the allowable amount of BOD that may be present at a given critical reach in the watercourse. Suggestions for future research are given.

128
A SUMMARY OF THE HOPKINS STORM DRAINAGE RESEARCH PROJECT: ITS OBJECTIVES, ITS ACCOMPLISHMENTS, AND ITS RELATION TO FUTURE PROBLEMS IN URBAN HYDROLOGY,

John C. Schaake
In: The Progress of Hydrology, Vol 2 - Specialized Hydrologic Subjects, Proceedings 1st International Seminar for Hydrology Professors, Jul 13-25, 1969. 28 p, 8 fig, 12 ref.

Descriptors: *International hydrological decade, *Urbanization, *Rainfall-runoff relationships, Research and development, Rational formula, Engineering, Hydrology, Hydraulics, Storm runoff, Model studies.
Identifiers: *Water resources research, *Urban hydrology.

Since its initiation in 1949, the Hopkins Storm Drainage Research Project had the following primary objectives: development of the

principles of hydraulic behavior of storm water inlets and the practical application of these principles to storm water inlet design practice; development of instruments for measuring and recording rainfall and storm runoff and the systematic collection of rainfall-runoff data; and development of the relationship between rainfall and runoff and application to storm sewer design practice. During the period 1949 to 1967, 52 locations were gaged. Some of these involved only a rainfall measurement, but 40 locations involved both rainfall and runoff gages. Some of the gaged catchments were sewered, but 29 of them were inlet areas. A computer model of the rainfall-runoff process was developed to predict runoff more accurately than any other method; it is based on sound physical principles , and runoff data are not required for its application.

129
STORM WATER FOR FUN AND PROFIT,

John R. Sheaffer
Water Spectrum, Vol 2, No 3, pp 29-34, Fall 1970. 7 fig, 1 tab.

Descriptors: *Storm runoff, *Planning, *Environmental engineering, *Multiple-purpose projects, *Benefits, *Water supply, *Recreation, *Flood protection, Retention.
Identifiers: *Storm water, *Potential resources.

A conceptual framework for storm water management is presented illustrating in several case studies opportunities to capitalize upon a wide range of benefits. The three basic principles in the framework are: (1) the environment is a single unit with air, land, water, and urban development interacting; (2) the earth for planning purposes is a closed system; (3) storm water is a potential resource out of place. The unity of the environment places storm water in a comprehensive perspective. Interchanges between surface and groundwaters and effects of urban land uses on distribution and quality must be recognized so that external costs will not affect drainage benefits. Considered within a closed system, the problem becomes one of space allocation. And viewed as a resource, location becomes an important factor. It is simply improper location that makes storm water a problem. When viewing storm water as a resource, quality must be carefully considered, particularly the initial flush which has been shown to be highly polluted. Therefore, a distinction must be made between detention and retention reservoir. When storm water is to be retained, it must be in an unpolluted condition or given treatment before storage. The six case studies discussed are: storm water management at the Flick-Reedy plant in Bensensville, Illinois; Leetsdale-Oneida Apartment development at Denver; Howard Gulch flood control project in Denver; skyline urban renewal project in Denver; Marcy Forest View Apartment development in Arlington Heights, Illinois; and the Indian Lakes storm drainage design in Bloomingdale, Illinois. All six cases illustrate in varying degrees the synergistic benefits of water supply, flood damage reduction, recreation, and open space.

130
PHYSIOCHEMICAL AND MICROBIOLOGICAL PROPERTIES OF URBAN STORM WATER RUNOFF,

G. Soderlund, H. Lehtinen, and S. Friberg
Fifth International Water Pollution Research Conference, San Francisco, Jul 26-Aug 1, 1970. Preprint Paper I-2. 8 p, 18 fig.

Descriptors: *Storm runoff, *Chemical properties, *Microbiology, Sampling, Nitrogen, Phosphorus, Water pollution effects, Snowmelt.
Identifiers: Urban runoff, Lead, Suspended solids, Sweden.

In Sweden today a separation of storm and sanitary sewers is usually preferred. This avoids the discharging of mixed storm water and wastewater into the streams and inland waters. There is an increasing discussion as to whether the direct discharge of storm water into streams can be justified for the future. A study to collect more information concerning the nature and extent of the pollutional load from highly urbanized areas was made. The results of this study showed that the discharging of snowmelt from heavily trafficed areas into streams and inland waters contributes in a great extent to the pollution of the recipients with oil and heavy metals. Traffic roads give a high degree of contamination as compared with the other test areas. The oil in the storm water is contaminated with oil not only from the traffic but also from the industrial areas. As the use of cutting oils and emulsions, dry cleaning liquids, and industrial cleaning liquids increases, the problem of collection and destroying such waste liquids must be solved. Various measurements were taken in areas differing with respect to traffic intensity. The analytical values obtained represent a skewed distribution. Nearly 50% of the dry residue obtained from warm water runoff is volatile material, most probably asphalt from the roadway and rubber from tires and oil. Other constituents measured in concentration versus time were chloride, pH, nitrogen, phosphorus, coliforms, carbohydrates, and BOD.

SECTION 7.

Legislation and Standards

131
ESTABLISHMENT AND OPERATION OF METROPOLITAN SEWERAGE COMMISSIONS,

8 Wis Stat Ann sec 59.96 (1957) as amended (Supp 1970).

Descriptors: *Wisconsin, *Cities, *Administrative agencies, *Sewage districts, Sewers, Water supply, Potable water, Sewage treatment, Legislation, Water pollution, Legal aspects.

In counties with more than 500,000 population, which have passed resolutions declaring the need for sewage disposal works, and which have qualified and appointed sewerage commissions, this Wisconsin legislation provides for appointment of sewerage commissioners. Metropolitan sewerage commissions may by resolution add to their district other areas within their county where such areas drain or may drain sewage into water which is or may be used as a source of drinking water. Procedures are outlined for adding such areas. The sewerage commissions have the power and duty to plan and construct sewers, pumping, and temporary disposal works for the collection and transmission of various types of sewage. Commissions may improve watercourses and divert water as long as they comply with procedures outlined in the statute. Commissions may promulgate rules and regulations for the operation of their systems and may acquire land needed to implement systems. Except as allowed by the statute, the commissions' power shall not extend to first class cities implementing their own sewerage system. Financing of improvements and tax levying procedures are also outlined.

132
CHELTENHAM AND ABINGTON SEWERAGE CO V PUBLIC SERVICE COMMISSION (DEDICATION OF SEWERAGE SYSTEM),

162 A 469-473 (Pa 1932).

Descriptors: *Pennsylvania, *Sewers, *Rates, Drainage systems, Sewage disposal, Easements, Urbanization, Administrative agencies, Administrative decisions, Land tenure.
Identifiers: *Storm sewers.

Plaintiff sewerage company appealed an order of defendant public service commission abolishing plaintiff's charges for sewerage systems in two townships. The sewerage systems of the townships were installed by a promoter along with surface drainage improvements. The promoter formed plaintiff corporation, but did not convey his

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rights in the system to plaintiff until after the sale of a number of lots in certain subdivisions. The promoter's conveyances to the lot owners did not deserve any rights to the sewerage system. No charges for the storm sewers had been made for 30 years. Defendant contended that these circumstances proclaimed the promoter's intent to dedicate the sewerage system to the public, and hence plaintiff did not own the system. Sustaining this contention, the court noted that the residents had a drainage easement wherever the promoter had installed drains in natural watercourses and held that plaintiff could not extract charges for the system. Plaintiff further contended that one of its employees cleaned the system after heavy rains three or four times a year, but the court held that this service did not justify compensation. Defendant's order was affirmed.

133
HALE VERSUS KANSAS CITY, MO (CITY'S LIABILITY FOR FLOOD DAMAGE CAUSED BY FAILURE TO OPEN FLOODGATE DURING RAINSTORM),

187 SW2d 31-41 (Mo Ct App 1945)

Descriptors: *Flood damage, *Storm drains, *Flood gates, Settlement (structural), Runoff, Water injury, Judicial decisions, Sewers, Cities, Backwater, Flood control, Drainage systems.
Identifiers: *Kansas City, Missouri.

Plaintiff paper bag company brought action against defendant city for flood damage to plaintiff's building caused by defendant's failure to open the sewer system's main floodgate during a heavy rainstorm. Plaintiff contended that no flooding would have occurred if defendant had opened the main storm drain and operated its drainage pumps. Defendant argued that submission of plaintiff's contention to the jury was improper since the purpose of the floodgate was not to facilitate the sewage system's flow, but to prevent water from the river from backing up into the sewer system during high water. Affirming a judgment for plaintiff, the court held that regardless of the primary purpose of the floodgate, the jury properly heard and decided the question of whether defendant's failure to open the gate during the rainstorm was the proximate cause of the damage to plaintiff's building.

134
FREEMAN V CITY OF LAKEMILLS (LIABILITY FOR INJURY CAUSED BY NATURAL PROCESSES),

243 Wis 537, 11 NW2nd 181-182 (1943).

Descriptors: *Wisconsin, *Natural flow, *Channel morphology, *Storm runoff, Storm drains, Surface water, Sewers, Creeks, Seepage, Legal aspects, Drainage practices, Relative rights, Flooding, Overflow.

Plaintiff landowner brought action to abate an alleged nuisance and for damages for injury to his property. Plaintiff contended that seepage into his basement was caused by the overflow of a natural watercourse adjacent to his property into which flowed surface water from defendant city's storm sewers. Plaintiff contended further that such action by defendant caused refuse deposition in the creek and caused the bed of the creek to be raised, and that the channel change which resulted from the raising of the bed caused the overflow. Defendant admitted only that it had used the creek for an outlet for its storm water, and contended that the evidence did not support the trial court's judgment for plaintiff. The Supreme Court of Wisconsin held that a city has the same right with reference to surface waters as an individual would have. Cities are not liable to riparian owners for material and water that flows from their streets into surrounding streams. The change in the channel of the creek and the raising of the water was a natural process for which no legal liability could be placed on defendant. The judgment for plaintiff was reversed.

135
CASHIN V CITY OF NEW ROCHELLE (DAMAGES FROM OVERFLOW OF STREAM),

256 NY 190, 176 NE 138-140 (1931)

Descriptors: *New York, *Overflow, *Flood damage, Cities, Streams, Discharge (water), Drainage practices, Sewers, Drainage systems, Legal aspects, Judicial decisions, Riparian rights, Flooding.

Plaintiff landowner sought to recover damages to her property. The damages were allegedly caused by defendant city's collection and subsequent discharge of water into a stream flowing through plaintiff's property. It was argued that such discharge caused the stream to overflow and flood plaintiff's lands. Plaintiff further sought removal of an earth mound left by the city when it constructed a sewer through plaintiff's property. The trial court gave judgment for plaintiff, and defendant appealed on the measure of damages. The New York Court of Appeals, reversing the lower decision, ruled that damages for the overflow of land must be based on the difference between the rental value of such land without the overflow and the rental value with the overflow. The court further ruled that the leaving of the mound was merely a breach of condition of the right-of-way granted to defendant by plaintiff's predecessor. Such condition was for the benefit of the grantor only and gave plaintiff no claim against defendant. A new trial was ordered.

136
LEISL V CITY OF NEWPORT (LIABILITY FOR OVERFLOW RESULTING FROM INADEQUACY OF CULVERT),

258 Ky 506, 80 SW 2d 556-557 (1935)

Descriptors: *Kentucky, *Flooding, *Excessive precipitation, Flood damage, Overflow, Rain water, Judicial decisions, Flow, Conduits, Streams.

In an action for damages, plaintiff contended that defendant municipality negligently constructed and maintained a culvert in a creek. Plaintiff contended that the culvert was inadequate to carry off the waters of the creek in heavy rains, and that such culvert caused waters to back up upon his property, thereby flooding and damaging it. Defendant contended that its duty in maintaining the culvert was to allow for carry off of water during ordinary rains, but not during heavy rains. The court held that one constructing and maintaining a culvert in a creek not adequate to carry off the water during ordinary rains is liable in damages caused by any overflow. However, the court held that there was no liability for such overflow resulting from extraordinary or heavy rains. The court affirmed the trial court's granting of defendant's demurrer since plaintiff's complaint alleged that the overflow resulted from heavy rains.

137
WILKINSON V CITY OF INDIANOLA (OVERFLOW OF CITY SEWAGE SYSTEM),

278 NW 326-327 (Iowa 1938).

Descriptors: *Iowa, *Sewers, *Overflow, *Municipal wastes, Drainage systems, Sewage disposal, Storm drains, Storm runoff, Public health, Judicial decisions, Legal aspects.

Plaintiff property owner sued defendant city for damages resulting from the overflow of municipal sewage onto plaintiff's land. Defendant had opened the surface water intake to a sewer, although the sewer was solely designed for sewage disposal and was inadequate for storm sewer purposes; the sewer had overflowed onto plaintiff's land on several occasions. Plaintiff contended that defendant was negligent in opening the storm intakes. The court held that the evidence was sufficient to be presented to the jury, and affirmed the judment of the lower court for plaintiff.

138
TRUSTEES OF UNIVERSITY CO-OPERATIVE CO V CITY OF MADISON (DUTY OF CITY TO MAINTAIN CITY SEWER SYSTEM),

288 NW 742-747 (Wis 1939).

Descriptors: *Wisconsin, *Storm drains, *Flood damage, *Drainage effects, Damages, Sewers, Rainfall intensity, Seepage, Surface waters, Judicial decisions, Legal aspects, Storm runoff, Drainage systems.

Plaintiff brought action to recover damages for injury to his property allegedly caused by defendant city's defective and clogged storm drain to which plaintiff's roof drainpipe connected. The court found the evidence to be sufficient to support the verdict that defendant was negligent in damaging the storm drain used by plaintiff and in failing to repair the defect after receiving notice thereof. The court stated that if a duly adopted and executed plan of sewage disposal becomes out of repair to the knowledge of the municipality, the duty devolves upon it to remedy the matter, and it is liable for failure to exercise ordinary care in respect thereto. The judgment for plaintiff was affirmed except as to a part of the damages allowed. As to that part of the damages, a new trial was ordered.

139
HERSHEY BEVERAGE CORP V CITY OF SCHENECTADY (MUNICIPAL LIABILITY FOR FLOOD DAMAGE),

291 NYS 256-257 (App Div 1936).

Descriptors: *New York, *Sewers, *Flood water, *Storm runoff, Judicial decisions, Legal aspects, Damages, Storm drains, Storms, Outlets, Maintenance.

Plaintiff corporation brought a negligence action against defendant city for damages which resulted from flooding of its premises. Defendant allegedly had failed to install and maintain sewers adequate to drain rainfall without flooding a particular street and had improperly installed a sewer drain in such street. From a jury verdict for defendant, plaintiff appealed. In affirming per curiam, the court held that the jury could have reasonably found that plaintiff's cellar was damp at all times, that his premises were in a low section of the city, that the sewers were adequate, that the rainfall causing the damage was of extraordinary quantity, and that plaintiff's own outlets to sewers were improperly maintained.

140
ROSITZKY V BURNES (FLOOD DAMAGE TO ADJACENT BUILDING CAUSED BY OVERFLOW FROM ROOF),

295 SW 830-833 (Mo 1927)

Descriptors: *Missouri, *Drains, *Flood damage, Rainfall, Overflow, Storm drains, Legal aspects, Floods, Roofs, Pipes.

In an action to recover water damages, plaintiff alleged that defendant had allowed gravel and other trash to accumulate on defendant's roof. During heavy rainfall, runoff from defendant's roof overflowed onto plaintiff's adjacent building, carrying with it much of this trash and clogging plaintiff's drains. Water was therefore backed up into plaintiff's building, causing flood damage. The court found that plaintiff's drains were negligently clogged. However, defendant contended that it did not occupy the premises in question, but leased it to a third party, and that under Missouri law a lessor was not liable for such damage caused while the tenant was in possession. The appellate court, however, found that there was no allegation or evidence of any lease in the record. Defendant was therefore held liable for the damage caused by the overflow.

141
LATHAM V DES MOINES ELECTRIC LIGHT CO (WATER DAMAGE CAUSED BY BURSTING STORM SEWER),

296 NW 372-376 (Iowa 1941).

Descriptors: *Iowa, *Storm runoff, *Sewers, *Electrical equipment, *Water injury, Drainage systems, Storm drains, Underground structures, Water pressure, Judicial decisions, Legal aspects, Damages, Surface runoff.

Plaintiff building owner sued defendant electric company for damages to his building caused by a broken sewer. Defendant had installed an electrical conduit across a sewer which was laid under the street in front of plaintiff's building. The conduit occupied the top 40% of the sewer's interior diameter. During a heavy rainfall, the sewer burst at the conduit-sewer intersection, causing the water to escape, wash away the foundation of plaintiff's building, and collapse a wall. Plaintiff contended that defendant had negligently installed the conduit so as to obstruct the sewer and that this was the proximate cause of his injury. The court stated that defendant should have used reasonable care in installing the conduit, and that defendant was negligent if it had obstructed the sewer so that injury to others was reasonably apparent. Finding that the evidence established a question for a jury, the court held that the lower court had erred in directing a verdict for defendant.

142
CHELTENHAM AND ABINGTON SEWERAGE CO V PUBLIC SERVICE COMMISSION (OWNERSHIP OF STORM DRAINAGE SYSTEM),

311 Pa 175, 166 A 649-652 (1933)

Descriptors: *Pennsylvania, *Storm drains, *Surface runoff, Urbanization, Drainage system, Sewers, Streams, Judicial decisions, Legal aspects, Storm runoff.

Plaintiff sewerage company appealed an order of defendant Public Service Commission which denied plaintiff's request for permission to charge for storm drainage service. Plaintiff's predecessor had installed conduits in streambeds to form a storm drainage system for a subdivision. A sewerage system was also installed by plaintiff's predecessor, separately and disconnected from the storm drainage system. Defendant contended that plaintiff did not own the storm system. The court determined that a conveyance to plaintiff by the subdivision promoter included only the sewerage system, and that if the storm system had been included, charges could not be exacted for its use, since the storm system was merely a substitute for natural drains. Property owners have a right to use artificial conduits for drainage of surface waters formerly carried away by natural streams. Furthermore, the court noted that there was meager evidence of maintenance of the storm system or other indications of ownership. The court held that plaintiff did not own the storm drainage system and consequently could not charge for its use.

143
LIABILITY OF A WATER AND SOIL PROTECTION AGENCY FOR FLOOD DAMAGE,

E. Hussla
Wasserwirt, Vol 61, No 2, pp 54-55, Feb 1971.

Descriptors: *Flooding, *Flood damage, Flood protection, Judicial decisions, Overflow, Legal aspects.
Identifiers: *Germany.

In the years 1957 and 1958 a river flooded the premises of a business woman who was not a member of the Water and Soil Protection Association. The flood caused damage to the business she was operating on these premises. When she filed suit against the Association and demanded that they make good for the flood damage she suffered, the municipal and state courts upheld her charges. The federal court declined a revision of the case and upheld the verdicts of the lower courts. It was stated that the accused Association had the task of protecting the area against floods by construction of dams and that this task also extends to the premises of non-members.

SECTION 8.

Treatment Methods and Reuse

144
TESTS MICROSTRAINING AND OZONE ON STORMWATER OVERFLOW,

Am City, Vol 86, No 1, pp 28, Jan 1971.

Descriptors: *Waste water treatment, Ozone, Pilot plants.
Identifiers: *Storm water overflow, *Microstraining, *Philadelphia, Pennsylvania, Ozonation, Combined sewers.

A pilot-plant study, experimentally undertaken to combat storm water overflows from combined sewers located in the Philadelphia area, embraced microstraining to remove the polluting solids and ozonation to disinfect the effluent. The pilot plant draws a portion of the overflowing wastewater containing raw sewage and settled solids to a Crane Microstrainer, a revolving drum with the perimeter covered by a specially woven stainless steel wire cloth. The storm water enters through one end of the drum and flows outward through the metal fabric leaving behind the polluting suspended solids which are carried upward to the top of the drum where wastewater jets flush them down into a receiving hopper on the axle of the drum. The storm water then flows to a holding tank where it is treated with ozone for sterilization and elimination of possible viruses and bacteria. To generate the ozone, air passes through refrigeration coils, through silica-gel desiccators, and then flows through a narrow discharge gap between electrodes operating at 15,000 volts, thus becoming ozonated.

145
PHYSICAL-CHEMICAL TREATMENT OF SEWAGE,

Effluent Water Treat J, Vol 10, No 11, pp 673, Nov 1970.

Descriptors: *Sewage treatment, *Pilot plants, *Laboratory tests, *Activated carbon, Coagulation, Sludge, Costs.
Identifiers: *Storm sewage, *Combined sewers, *Chemical treatment, Battelle Northwest Institute.

A physical-chemical system for treatment of combined storm sewage is being developed on a pilot plant scale by the Battelle Northwest Institute in Washington. Laboratory studies have attempted to optimize a process for solids and organic removal with minimum detention time and chemical doses. The evolving process uses powdered activated carbon at 600 to 1000 mg/1, coagulation with alum (200 mg/1) and polyelectrolyte (2.5 mg/1), followed by high-rate tube settling, and with an overall detention time of 30 minutes. The sludge, containing

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carbon and aluminum hydroxide was thermally regenerated by two alternative processes, each giving about 90% carbon recovery. Sulphuric acid extraction of the regenerated mixture recovered about 85% of the alum. Preliminary costs indicate 18.9 cents/1000 U.S. gallons and a capital cost of $1.2 million for 10 mgd (U.S.) plant. The 0.1 mgd capacity pilot plant is mobile and is equipped with instruments for continuously recording flowrates, pH, turbidity, and organic carbon.146
REGIONAL SEWER SYSTEM IS NO DREAM IN DETROIT,

Eng News- Record, Vol 185, No 24, pp 24-25, Dec 1970.

Descriptors: *Water pollution control, *Treatment facilities, *Planning, Sewage treatment, Storm runoff, Overflow, Construction, Costs.
Identifiers: *Detroit, Michigan.

The Detroit Metropolitan Water Department's plant to incorporate six counties into a massive regional sewage collection and treatment system that will reduce water pollution in the Great Lakes and connecting waters and seven rivers was discussed. The first of the three phases of the 4,000 square mile area construction plan consists of the erection of a 28 mile long intercepter. By 1975, DMWD plans to have an additional $290 million in treatment plants and interceptors under construction. Advantages include a 600-mgd oxygen operated aeration tank for the activated sludge process, 2 additional primary sedimentation tanks adding 300-mgd to the sewage treatment capacity, a 1.2-mgd chlorine contact conduit, and phosphate removal facilities. Phase 2 brings in 4 counties and phase 3 will expand the system to the entire metropolitan area with an estimated population of 8.5 million. Because storm water flow is a major contributor to the pollution of southern Michigan streams, DMWD is installing a monitoring system to detect approaching storms which comprises rain gages, sewer level sensors and overflow detectors connected to a central computer, datalogger and operating console that activates pumping stations, and selected regulating gates.

147
NEW SEWAGE TREATMENT WORKS FOR BLYTH AND MORPETH,

Surveyor, Vol 136, No 4097/4098, pp 44-46, Dec 1970.

Descriptors: *Sewage treatment, *Treatment facilities, *Equipment, Sewage disposal, Separation techniques, Flow separation, Sludge treatment, Storm runoff, Storage tanks, Drainage systems, Tertiary treatment.
Identifiers: *Great Britain.

An overall sewage disposal scheme, whose first stage provides primarily for a newly constructed foul and surface water drainage system, has been developed for the whole of Blyth. The existing inlet works, comprising mechanically raked screens, flow recorder, detritus channels, and storm water overflows, have been retained in stage one. Flows between 3 DWF and 6 DWF are separated and passed to the original three sedimentation tanks, which are now serving as storm water tanks and have a combined capacity of 168,750 gallons. Primary settlement takes place in two rectangular, horizontal flow tanks with a capacity of 333,000 gal.; settled sewage passes to four aeration tanks, each of which is fitted with a high intensity aeration cone driven by a 10 hp motor; and sludge treatment units comprise an elevated circular sludge storage tank, two circular conditioning tanks, lime and copperas mixing tanks, and the filter press house. The Morpeth works have been designed to treat a DWF of 915,000 gpd with tertiary treatment to meet standards of 20 mg/l suspended solids and 15 mg/l BOD. Flows in excess of 6 DWF are passed over a storm overflow weir to the river without further treatment, and flows from 3 DWF to 6 DWF receive partial treatment in storm water tanks before being discharged. Settled effluent passes via a flow dividing chamber and two dosing chambers to seven percolating filters; filtered effluent passes through a flow dividing chamber to two circular, mechanically scraped humus tanks, where finer solids settle out; two microstrainer units provide tertiary treatment for humus tank effluent; and sludge is pumped continuously from the storage wells to a small conditioning tank where lime and copperas are added before it gravitates to a sludge bath in which the bottom of the filter drum is immersed.

148
SOUTHWEST U.S. FACES RESOURCES PROBLEMS,

Water Wastes Eng, Vol 8, No 2, pp 31, Feb 1971.

Descriptors: *Water supply, *Feasibility studies, *Water resources development.
Identifiers: *Southwest U.S.

Because of the lack of an adequate surface source, the entire supply of water to the urban and metropolitan areas in Southwest U.S. come from groundwater storage. In order to prevent the rapid decline of the water table and possible exhaustion of groundwater supplies, supplemental supplies of water must now be investigated and developed for the Tucson Metropolitan area. The use of secondary sewage effluent in irrigation, the reclamation of domestic wastewater, the value of storm runoff for reuse, and the analysis of storm water from various urban watersheds are being studied for application in regions such as Tucson where resource problems are critical.

149
CHEMICAL TREATMENT OF COMBINED SEWER OVERFLOWS,
The Dow Chemical Company

EPA/WQO Contract No 14-12-9, Program No 11023 FDB, Sep 1970. 185 p, 56 fig, 50 tab.

Descriptors: *Cost analysis, *Disinfection, *Flocculation, *Overflow, *Sedimentation, *Sewage, *Storm runoff, *Settling basins, *Hydraulic design, *Water analysis, Coliforms, Design storm, Rainfall-runoff relationships.
Identifiers: *Combined sewage, *Milk River, *Detroit, Michigan, *Combined sewers.

A typical pumping station and settling basin, characteristics of combined sewage overflows, and chemical treatment with chemical flocculants and disinfectants are described. Average number of days of pumping per year (41) is about equal to average number of days with precipitation $\geq$0.2 inches (45). Twenty-two analyses of consecutive time-weighted samples of influent and effluent are reported for 33 storms over a two-year period. Biochemical oxygen demand and suspended solids decreased after initial flushing of the sewers; chlorine demand was relatively constant. The discharge channel and immediate receiving bay were severely polluted. Cationic polymeric flocculants and flocculant aids significantly improved removal of suspended solids from combined sewage in the laboratory. Adequate disinfection of the combined sewage before discharge is possible. Performance of the existing basin can be improved by the use of staged continuous pumping at lower rates and the addition of baffles for improved flow distribution.

150
NEW APPROACH TO APPLIED RESEARCH,

Irvin M. Rice
Water Wastes Eng, Vol 8, No 2, pp 20-22, Feb 1971.

Descriptors: *Pilot plants, *Treatment facilities, *Storm runoff, *Urbanization, *Contracts, *Research and development, *Infiltration, Water reuse, Feasibility studies.
Identifiers: *Sewer flow, *Dallas, Texas.

The existing contract between the City of Dallas and Texas A & M University may prove to be of far-reaching importance in the search for solutions to the twin problems of providing an adequate water supply and alleviating the pollution problem in streams. Under the terms of the contract, the foundation agreed to direct and administer the Dallas wastewater and water reclamation programs at the research center. Direction, with an objective of finding an answer to the problem of handling excess flows in sewers caused by storm water infiltration, is given to the pilot operation of a storm water treat-

ment facility. The long term objective of the combined effort is to fully exploit the potential of the water reclamation center in developing improved treatment processes to meet more stringent pollution control demands of the coming decade. Results from the pilot plant study indicate that allowable infiltration tolerances have been progressively reduced and for new sewer construction the upper limit is 300 gpd per inch of pipe diameter per mile. A study is in progress to determine the extent of infiltration into the older house laterals and collectors and to develop a feasible program of tightening up the older parts of the system.

151
URBAN WASTE STABILIZATION POND,

Norman Van Sickle
Water Sewage Works, Vol 117, No 12, Dec 1970. 1 fig.

Descriptors: *Sewage lagoons, *Treatment facilities, *Separation techniques, *Project feasibility, Overflow, Systems analysis, Urban renewal.
Identifiers: *Combined sewers, Storm water overflow.

Sewage lagoons require very little treatment mechanisms and maintenance expenditures are nominal. When satisfactorily operating, a pond is facultative; it has an aerobic zone in the bottom portion, but becomes aerobic in the upper levels. Solids settle to the bottom and undergo anaerobic decomposition, but the odorous products of these are oxidized on the way to the surface. In the past lagoon or pond treatment has been considered applicable only to rural areas. In the consideration for the application of works to urban waste treatment the following factors would enter: 1) area for treatment purposes with the required oxygen content, 2) temperature control for optimum algae growth, and 3) algae removal before it becomes a pollutant. It may be practically and economically feasible to use ponds that are very deep, that use submerged artificial light, and that maintain a favorable temperature, especially bearing in mind the practicability of maintaining three or four layer stratification within the cell. To combat back-ups in combined sewers during storm flow conditions, new separate sanitary sewage collection systems would be less costly than under present system practice provided the deep treatment cells proved practicably sound for urban use.

152
WASTE WATER AND STORM FLOW TREATMENT (LITERATURE REVIEW),

D. J. Weiner
J Water Pollution Control Fed, Vol 42, No 6, pp 963-969, Jun 1970.
42 ref.

Descriptors: *Storm runoff, *Waste disposal, *Sewerage, *Sewers, *Overflow, Waste water treatment, Pipes, Construction, Operation and maintenance.
Identifiers: *Treatment methods, Storm sewers, Combined sewer overflow.

The role of wastewater transportation, control, and treatment was being reemphasized as part of the requirements in improved control and improvement of the environment. New communities have demanded sewerage services and older municipalities expanded sewage facilities into new areas as they found that residents expected to receive adequate sewage facilities into new areas as they found that residents expected to receive adequate sewage services. Sewers continue in importance as an economical and efficient means of waste disposal. Several reports presented various aspects and problems connected with different types of pipes for sewage use. These included clay pipes, concrete pipes, asbestos concrete pipes and PVC pipes. Maintenance programs and safety programs were described in several papers. Also presented were construction programs incorporating pipe testing and root control methods for new and renovated sewers. The control and treatment of overflows from combined sewers have attracted attention and interest of several papers as the total water pollution control program grows. Regulation and treatment of overflows have been investigated in the United States and other countries. A variety of programs in several cities for treatment of the combined sewer overflows were discussed.

SECTION 9.

Hydrology

153
FLOW DISTRIBUTION IN STREET INTERSECTIONS AS DETERMINED BY EXPERIMENTAL HYDRAULIC MODEL STUDIES,
Los Angeles Bureau of Engineering, California, Storm Drainage Division

1952-1953. 63 p, 59 fig.

Descriptors: *Storm runoff, *Flow rates, *Flow measurement, *Water measurement, *Drainage systems, *Hydraulics, *Drainage engineering, *Model studies, Urbanization.
Identifiers: *Street intersections, *Street drainage, *Los Angeles, California.

The publication is an assembly of 59 different sets of charts which can be used in designing urban streets and drainage systems. The charts were developed for determining storm runoff flow distribution in right-angle street intersections. Each chart reflects predetermined prototype inflow quantities of water which may reach a right angle cross-street intersection from two directions under varying conditions of street widths, slopes, crowns, and crossfalls. Based upon a given set of conditions, the distribution of the combined inflow can be determined at the street intersection as it emerges from the intersection, in the two outflow street sections. These calculated quantities can then be used in the design of street storm water inlets, catch basins, and storm sewers. The charts were developed from experimental hydraulic model studies conducted by the City of Los Angeles over a 16 month period. The models were built to a 1:15 scale. Much of the data was developed from an adjustable model, in which the significant physical parameters could be varied to simulate prototype conditions worthy of study. Initially, the work was jointly sponsored by the California State Division of Highways and the City of Los Angeles. The City later continued and expanded the studies to result in the subject publication.

154
URBAN HYDROLOGY,

W. J. Bauer
In: The Progress of Hydrology, Vol 2 - Specialized Hydrologic Subjects, Proceedings 1st International Seminar for Hydrology Professors, Jul 13-25, 1969. 33 p, 3 fig, 3 tab.

Descriptors: *International hydrological decade, *Urbanization, *Storm runoff, *Rainfall-runoff relationships, Research and development, Mathematical models, Cost-benefit analysis, Water resources development, Hydrology, Hydraulics, Water quality control, Planning, Illinois.
Identifiers: *Water resources research, *Urban hydrology.

This paper presents viewpoints of a practicing consulting engineer concerning the following aspects of urban hydrology: the controlling economic factors; the need for improved analytical and design techniques; and the use of simplified methods pending the gathering of data required for the use of improved techniques. The northeastern Illinois metropolitan area is used as an example in illustrating each of these aspects. Storm runoff in urban areas takes up valuable space, and only the location of this space is subject to engineering control. Therefore it is the volume of runoff more than the rate of runoff which is important to evaluate for design purposes. Runoff from urban areas presents a quality control problem. Therefore it behooves the planner to move in the direction of large storage and small rates of flow, because of the high cost of treatment at high rates of flow for short periods of time. All methods of analysis of storm runoff and the associated flow in open channels involve the use of mathematical models. Every decision regarding storm drainage, even one to do nothing, involves an allocation of space for the temporary storage of storm water, and therefore involves an acceptance of the cost associated with that decision.

155
MEASUREMENT PROCEDURES FOR THE PLANNING OF SEWER SYSTEMS,

Ernst Billmeier
Ber Inst Wasserwirt Gesundheitsingenieurwesen, No 4, pp 1-185, 1970.

Descriptors: *Sewers, *Sewerage, *Measurement, *Planning, *Storm runoff, *Storm drains, Drainage.
Identifiers: *Parametrics, Hydraulic calculations.

The measurement procedures available for the calculation of three types of storm drains in mixed and separate systems contradict recent findings and should no longer be used. The author has attempted to incorporate storm water drainage parameters into more recent measurement procedures with the view of drawing diagrams for practical application. The use of these diagrams is demonstrated on several examples. A comparison of calculation procedures for the various storm drain types brought to light their respective differences and served as a check on the suitability for their dimensioning. Hints concerning the construction of such drains are offered.

156
FORECASTING THE VOLUME OF STORM RUNOFF USING METEOROLOGICAL PARAMETERS,

Robert Hasbrouck Cartmill
University of Oklahoma Thesis, 1970.

Descriptors: *Runoff forecasting, *Storm runoff, *Methodology, Meteorological data, Analysis, Measurement, Instrumentation.
Identifiers: *Infiltration rate, Parametrics.

This work develops a method forecasting runoff volume without reliance on any empirically derived relationships between meteorological parameters and recorded runoff measurements. The method is therefore applicable to areas where there are no existing meteorological or hydrological records. This method determines the infiltration rate by use of an approximate solution to the soil moisture diffusion equation. This solution requires knowledge of the existing soil moisture content, the saturated soil moisture content, and the saturated hydraulic conductivity at all depths of the root zone. The variable amount of soil moisture in nine district layers of soil is determined daily by maintaining a water budget of the 51 inch layer of soil which is assumed to constitute the root zone. The water budget contains the factors of rainfall, interception losses, runoff, the redistribution of infiltrated rain soon after infiltration, drainage from each layer, and evaportranspiration. After the parameters required to determine the infiltration rate are available, the infiltration rate is compared with the rainfall rate every minute. The excess of rainfall over infiltration is then consigned first to depression storage and then to runoff. This method was applied to two major and thirteen smaller storms over a 208 square mile watershed in South Central Oklahoma. The runoff forecast by the method was compared with the measured runoff from the watershed. Conclusions are reached concerning the area of applicability of the method, the instrumentation required, and the limits of accuracy of the method.

157
COMPUTER SIMULATION OF URBAN STORM WATER RUNOFF,

Carl W. Chen and Robert P. Shubinski
J Hydraulics Div, Am Soc Civil Engrs, Vol 97, No HY2, pp 289-301, Feb 1971. 9 fig, 1 tab, 12 ref.

Descriptors: *Hydraulic models, *Hydrography, *Hydraulics, *Runoff, *Computer programs, *Storm runoff, Overland flow, Open channel flow, Drains, Model studies, Simulation analysis.
Identifiers: *Urban hydrology.

As part of an overall storm water management program, a model was developed to simulate the runoff phenomena of a drainage basin for any given rainfall pattern. The model represents the basin by an aggregate of idealized subcatchments and gutters. The computer is instructed to make a step-by-step accounting of rainfall, infiltration, detention, overland flow, and gutter flow in the calculation of a hydrograph. Three preliminary simulations are made to demonstrate the validity of the method.

158
WHERE IS URBAN HYDROLOGY PRACTICE TODAY?

D. Earl Jones
J Hydraulics Div, Am Soc Civil Engrs, Vol 97, No HY2, pp 257-264, Feb 1971. 15 ref.

Descriptors: *Storm runoff, *Storm drains, *Runoff forecasting, *Hydraulics, Drainage, Drainage effects, Rational formula, Flood routing.
Identifiers: *Urban hydrology.

The evolution of urban street construction and its effects upon urban drainage is traced. Rational method development and inconsistencies in its application are summarized. The emphasis is on lack of absolute precipitation data with resultant inhibiting effects upon development of improved runoff prediction methods. Need for two drainage systems on each urban drainage area is defined. It indicates dual system dividends are reduced drainage costs, reduced flooding losses, and the opportunity to enhance property values, stabilize neighborhoods, and improve urban life quality. Some basic methods for managing urban runoff are also indicated to attenuate peak flows. A low maintenance channel is identified as being more realistic than usual urban channel designs. It points out that direct losses from and expenditures for urban drainage approximate four billion dollars per year.

159
A METHOD FOR RUNOFF-MAPPING FROM PRECIPITATION AND AIR TEMPERATURE DATA,

H. Liebscher
In: Symposium on World Water Balance, Vol 1, No 92, pp 115-121, Jul 1970. 3 fig, 8 ref.

Descriptors: *Water balance, *Mapping, Rainfall-runoff relationships, Data collections, Data processing, Maps, Hydrologic cycle, Runoff, Streamflow.
Identifiers: *West Germany.

A simple method is given for obtaining runoff maps from precipitation and air temperature data. It has proven of considerable practical value in the Federal Republic of Germany. The procedure can also be used for determining the long-term depth of runoff in areas for which runoff data are not available. Of all related factors, precipitation is the one that exerts the strongest influence on mean runoff depth and specific yield. If approximate evapotranspiration values for all stations concerned have been determined from precipitation and air temperature data, it is possible to get from the difference between precipitation and evapotranspiration approximate information on long-term mean runoff depth or specific yield. With the aid of the maps thus obtained, it is easy to determine the values required for water balance by plainmetering the areas between the isolines.

160
EXAMINATION OF RAIN WATER LOSS MECHANISM IN AN URBAN AREA,

Shigeaki Matsubara and Masai Yokoo
In: Proceedings of the Seventh Conference on Sanitary Engineering Research, Japan Society of Civil Engrs, Committee on Sanitary Engineering, Jan 30-31, 1971. 157 p.

Descriptors: *Infiltration, *Discharge (water), *Rainfall-runoff relationships, Data collections, Investigations, Water loss, Mathematical studies, Forecasting.
Identifiers: *Urban hydrology, Quantitative analysis, Japan.

In an urban area, surface conditions characterized by infiltration and non-infiltration areas are considered to be the significant factors that control the outflow phenomena. Weak rainfall in an urban area results in outflow from the non-infiltration area, and strong rainfall in the combination of outflows of both infiltration and non-infiltration areas. Based on the data obtained during an investigation and non-infiltration areas. Based on the data obtained during an investigation on the rainwater outfall in an urban area, outflow coefficients and water losses are calculated. Furthermore, through quantitative analysis various mathematical formulations are examined. It is concluded that although mathematical tools such as the peak-flow quantity formula will continue to be used in the future, further improvements are necessary to allow more accurate forecasting and to obtain more precisely the loss mechanism in an urban area.

161
RUNOFF - A POTENTIAL RESOURCE,

Eric F. Mische and Vishnu V. Dharmadhikari
Water Wastes Eng, Vol 8, No 2, pp 28-31, Feb 1971. 4 tab, 10 ref.

Descriptors: *Storm runoff, *Urbanization, *Research and development, Water pollution sources, Water quality, Sampling, Monitoring, Water treatment, Water reuse, Water resources, Water quality control.
Identifiers: *Urban hydrology.

The Water Resources Research Center and the Department of Civil Engineering at the University of Arizona have jointly undertaken a broad research effort that relates to the field of urban hydrology. This research has three general objectives involving both the quantitative and qualitative aspects of urban runoff. The results of only one phase of this study are presented in this article. Samples of runoff from three urban, natural watersheds of differing characteristics were analyzed in order to provide a basis for the evaluation of potential pollution effects and to initiate exploratory studies of treatment methods. In the absence of automatic sampling devices, grab samples were collected manually and used for analyses of ions, suspended and organic matter, and bacterial densities. The quality of water generally varied slightly from sample to sample in a given storm

and between different storms. It was observed that as the area becomes more developed the turbidity reduces. Results of suspended solids analyses follow a pattern similar to that of the reported turbidity findings. Data indicate that predominantly residential areas are not likely to contribute large amounts of TDS (total dissolved solids). The pollutional strength results, measured by the COD test, indicate that residential and commercial areas contribute approximately the same COD to runoff, while higher values were obtained from the waters in the industrialized watershed. It was shown that the removal of suspended solids alone greatly enhances the potential reuse of runoff waters. The study demonstrated that in human fecal material and in domestic wastes, fecal coliforms exceed the fecal streptococci by a ratio of 4 to 1. It is concluded that coagulation of urban runoff is effective; however, in reclaiming urban runoff, a sludge handling and disposal problem will result.

162
THE CONTRIBUTION OF RAIN RUNOFFS TO WATER POLLUTION,

Wilhelm J. Muller
Gas- Wasserfach (Wasser/Abwasser), Vol 112, No 1, pp 15-17, Jan 1971.

Descriptors: *Runoff, *Precipitation intensity, *Water pollution sources, Urbanization, Rainfall, Suspended load, Storm runoff.
Identifiers: *Germany.

In the Federal Republic of Germany the median precipitation (forty-year average from those measured between 1891 and 1930) is 803 mm/year. Of this 365 mm or 45.5% reach the ocean as direct runoff or indirect runoff or as wastewater. The runoffs carry along numerous substances in solved or suspended form. For assessment of the contribution of rain runoffs to water pollution, the runoffs from residential and industrial areas are of concern. Urban areas span 9.6% of the total surface on the Federal Republic. The rain runoff from these areas has been determined with 10,140 million cbm/year. They carry street dust, manure, leaves, abrasions from street pavements and rubber tires of vehicles, oil and fuel lost by vehicles, and other inorganic matter. The content of suspended matter is particularly high. The BOD ranges on an average of between 10 and 30 mg/liter. From tar and asphalt pavements carcinogenic matter is carried along. The great disadvantage of rain runoffs is that they burden the waterways spasmodically. With progressing urbanization it will become necessary to collect the rain runoffs and purify them before they can be entered into waterways.

163
AUXILIARY TABLES FOR THE HYDRAULIC CALCULATION OF OPEN ARTIFICIAL DRAINAGE DITCHES,

Rolf Pecher
Ber Inst Wasserwirt Gesundheitsingieurwesen, No 1, pp 1-17, 1969.
4 ref.

Descriptors: *Mathematical studies, *Drainage systems, *Ditches.
Identifiers: *Hydraulic calculations, *Flow velocity, *Drainage volume.

In accordance with ATV guidelines, the Gauckler-Manning-Stickler velocity equation and the Stickler velocity coefficient are used in the calculation of drainage ditches. The flow velocity and drainage volume are determined for the standard ditch profiles listed in DIN 19 556, evaluated for a gradient equalling 10 pro mille and for a velocity coefficient of 70 m 1/3/s and arranged in the form of tables. The conversion for any gradient and for any ditch wall profile is accomplished by means of conversion factors listed in a separate table. Drainage quantities and flow velocities as a function of the gradient and of filling depth for triangular ditches with a 90 or 60 degree base angle for the velocity coefficient of 70 m 1/3/s are listed in table form. Drainage volume and flow velocity for other velocity coefficients are determined with the help of conversion factors.

164
THE DRAINAGE COEFFICIENT AND ITS DEPENDENCE ON THE DURATION OF RAIN,

Rolf Pecher
Ber Inst Wasserwirt Gesundheitsingenieurwesen, No 2, pp 1-140, 1969.
151 ref.

Descriptors: *Storm runoff, *Mathematical studies, *Drainage, Rain water, Sewerage.
Identifiers: *Hydraulic calculations.

The storm water drainage process is analyzed and theoretical criteria are derived which permit a mathematical treatment of the process. The calculation takes into account losses caused by wetting and depressions, the surface incline, seepage as a function of time, type of soil, soil humidity and plant cover evaporation, and the duration and migration velocity of rain. The peak drainage coefficient and the median drainage coefficient are a function of the duration of rain. The three phases of drainage are its beginning, the rise of the floodwave, and its following the start of rain. The drainage coefficient is obtained through division of the drainage surfaces into permeable and impermeable partial areas by considering their wetting, depression loss, and seepage characteristics. The peak and median drainage coefficients which can be calculated as a function of rain yield,

duration, and frequency are not constant. The drainage coefficient, when introduced into the calculation of sewage systems, will yield more accurate data.

165
THE DIMENSIONING OF STORM DRAINS IN URBAN DRAINAGE SYSTEMS,

Rolf Pecher
Ber Inst Wasserwirt Gesundheitsingenieurwesen, No 3, pp 1-98, 1970.

Descriptors: *Storm drains, *Storm runoff, *Drainage systems, *Cities, *Rain water, Overflow, Reservoir storage, Basins.
Identifiers: *Hydraulic calculations.

Storm drains include rain retention reservoirs, storm water clearing basins, and storm water overflow basins. A new method of calculating storm drains of all three types is outlined. In the case of rain retention reservoirs the calculation method provides for variable drainage depending on the degree of filling, it can be adapted to any rain frequency and yields somewhat higher results than the Mueller-Neuhaus and the Lautrich graphic methods. The calculation of storm water clearing basins is predicated on an assumed retention time of between 10 and 20 minutes and on a stipulated clearing effect. The calculation of storm water overflow basins meets the condition that these not overflow until a critical rain level is reached (which condition is not met by the alternative Londong method).

166
STORM RUNOFF FROM CHAPARREL WATERSHEDS,

Raymond Martin Rice
Dissertation, 1970. 162 p.

Descriptors: *Hydrographs, *Runoff, *Storm runoff, Storms, Watersheds (basins), Rainfall.
Identifiers: *Canonical correlation, *Multiple regression.

Canonical correlation and multiple regression were used to predict runoff hydrographs from rainstorms on brush covered watersheds. The data used to develop the prediction equations were collected on the San Dimas Experimental Forest over a period of 21 years. They included 262 hydrographs representing the runoff from as many as 15 drainage basins during 35 storms. The resulting prediction equations were tested on 15 hydrographs from two watersheds and 34 storms. The similarity of predicted hydrographs based on multiple regression and canonical correlation analyses led to an inquiry which demonstrated that, when all canonical roots are used, multiple regression and canonical correlation are mathematically equivalent. Fifteen independent variables described the watershed condition and rainfall related to each of the hydrographs. Objective criteria were developed to

appraise the utility of the independent variables and the adequacy of sets of canonical correlations. For the study area it was found that the watershed physiography was not strongly related to runoff hydrographs. Prediction equations were greatly degraded by the arbitrary removal of either variables describing the vegetation and antecedent moisture of the watershed or variables which described the storm causing the runoff hydrograph. The lack of congruence between the observed and predicted hydrographs was mainly due to poor estimation of the peak discharge.

167
EFFECTS OF URBANIZATION ON RUNOFF FROM SMALL WATERSHEDS,

Puranam Bhaskara Seshardri Sarma
Dissertation, 1970. 307 p.

Descriptors: *Rainfall-runoff relationships, *Urbanization, Investigations, Analysis.
Identifiers: *Urban hydrology, Parametrics.

Urban and suburban development changes the quantity and time distribution of runoff. Investigation of the effect of urban development on the rainfall-runoff relationships was the main objective of this study. Quantitative evaluation of effect of urbanization on runoff would be relatively simple if rainfall and runoff data for both urban and pre-urban conditions of watersheds were available. Due to a lack of availability of such data, evaluation of changes in runoff characteristics caused by urbanization is not possible by direct data comparison and analysis. Data for the study were obtained principally from watersheds in West Lafayette, Indiana. Hydrologic data from several other urbanized watersheds were also used to make the study more general. The linear system analysis was used in the study. The single linear reservoir model, the double routing method, Nash model, the single linear-reservoir linear-channel model, and the Fourier transform method of obtaining the kernel function were used in the analysis of data. The parameters of the instantaneous unit hydrographs for the first four models were determined and also optimized for some of the conceptual models. Similarly, the kernel functions were determined by the Fourier transform method. The regeneration performance of all these models was then tested. The single linear reservoir model was selected to simulate the rainfall-runoff process on small urban watersheds. On the basis of its satisfactory regeneration performance and some other factors, the Nash model was similarly selected for simulation of the rainfall-runoff process on larger watersheds. The parameters of the single linear reservoir model and the Nash model were then studied in detail. The variation of the parameters and their relationships with the physiographic characteristics of the watersheds including the urbanization factor, and the storm characteristics, were studied mainly by using the techniques of regression analysis. From this analysis, the effects of urbanization on time lag, the magnitude of peak discharge, the time to peak discharge, and the frequency of peak discharge were quantitatively deduced.

168
DESIGN RAINFALL CHARACTERISTICS OF THE USSR TERRITORY,

E. A. Smirnova
In: Floods and Their Computation, Vol 1, No 84, pp 105-114, 1969.
2 fig, 3 tab, 3 ref.

Descriptors: *Design storm, *Hydrograph analysis, *Rainfall-runoff relationships, Rainfall intensity, Statistical methods, Hyetographs.
Identifiers: *USSR.

A method of processing hyetographs to obtain design rainfall characteristics used in maximum storm runoff computation is summarized. The technique provides, for a homogeneous climatic region: (1) the plotting of a curve of maximum depth increase with time interval increase and (2) the plotting of a curve of mean rainfall intensity decrease with time interval increase for certain exceedence or frequency probabilities. Depth of rainfall intensity for a required time interval can be determined for any point with known daily rainfall. Ordinates of reduction curves are only slightly dependent on frequency and change slowly. Curves of rainfall reduction have been plotted for different physiographical regions of the USSR and characteristics of the main types of reduction curves and their territorial distribution are given.

169
SOME EFFECTS OF URBANIZATION ON FLOODS,

John B. Stall, Michael L. Terstriep, and Floyd A. Huff
Meeting Preprint 1130, a paper presented at the ASCE National Water Resources Meeting, Memphis, Tenn, Jan 26-30, 1970. 29 p, 11 fig, 10 tab, 22 ref.

Descriptors: *Surface runoff, *Storm runoff, *Rainfall-runoff, relationships, *Peak discharge, *Urbanization, Hydrographs, Model studies, Floods, Illinois.
Identifiers: Design flood.

The objectives of the study were: (1) to attempt a better definition of the effects of urbanization on floods by using relatively good information available in Illinois on storm rainfall structure and frequency, and (2) to translate this into the resulting effect on the flood-frequency curve using a set of empirical equations developed in 1965 at the University of Texas Center For Research in Water Resources. The Texas equations were used as a transfer function from storm rainfall to flood peak. A model two-hour rainstorm, based on recorded precipitation data from East-Central Illinois, was developed for various recurrence intervals and applied to the completely urbanized, 3.5-square mile drainage area of Boneyard Creek at Urbana, Illinois. The specified model storm was applied to the derived unit hydrographs after determining the rainfall excess after losses. The empirical Texas equations seem adequate to produce a 30-minute unit hydrograph for the Boneyard basin and it checks favorably with actual

unit hydrographs. The complete transformation of a 3.5-square mile rural basin, in East-Central Illinois, to an intensely urbanized basin would quadruple the flood peak for the 50-year recurrence interval; and the mean annual flood would increase by about eight times.

SECTION 10.

Tunnels: Technology and Equipment

170
MACHINE TEAM MAKES SHORT WORK OF A LONG TUNNEL REACH,

Construct Methods Equip, Vol 53, No 1, pp 62-63, Jan 1971.

Descriptors: *Tunnels, *Tunnel construction, *Tunneling machines, Tunnel linings, Concrete construction, Tunnel hydraulics, California.
Identifiers: Tunneling shield.

Averaging 745 feet/week during the final 20 weeks of the 17,000-ft first-stage bore, miners driving a 22-ft diameter water tunnel 5 1/2 miles in soft dry sandstone under suburban Los Angeles recently holed through into a gate shaft and hall. Two machines made it possible to maintain the rapid pace through the tunnel's initial long reach: the tunneling shield, and a special tunnel-liner precasting jumbo that turned out 4-ft-long concrete liner segments at a clip of 12 per hour over an 80-hour week to support the shield's 144-hour weekly operation. The hydraulically powered shield, designed to make 8 feet per hour through ground similar to that encountered in the San Fernando bore, has a sliding boom with a total 11 ft of forward reach in two stages. The front of the shield is a cutting edge studded with teeth, and loss of top and center ground support causes material from the tunnel face to fall into a muck apron where it is dragged by the boom-head to a belt conveyor. The shield's hydraulic system is powered by electric motors that provide: 480 hp on the excavator functions, 160 hp on the shove jacks, 100 on the conveyor, and 60 on the erector. A laser and target guidance system keeps the shield on line, with the 5,000-psi jacks acting in unison within each quadrant to control alignment.

171
TUNNEL TO BE CUT BY ELECTRON-BEAM MACHINE,

Machine Design, Vol 43, No 5, pp 18, Feb 1971.

Descriptors: *Electronic equipment, *Rock excavation, *Tunneling, *Tunneling machines.

An electron-beam machine design for rock excavation will be field tested during the Spring by Westinghouse. This electron-beam method has the potential of reducing the cost and increasing the speed of drilling and tunneling by making use of a high-energy electron beam that melts deep but narrow cuts in rocks. In the process, the rock-cutting beam is passed through a series of small chambers which are pumped to preserve a partial vacuum, focused electromagnetically, and delivered to the surface where it is needed.

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172
DEVELOPMENT OF TUNNELING METHODS AND CONTROLS,

Ellis L. Armstrong
J Construct Div, Am Soc Divil Engrs, Vol 96, No CO2, pp 99-118, Oct 1970. 16 fig, 2 tab, 1 ref.

Descriptors: *Tunneling, *Tunnels, *Surveys, *Costs, *Safety, Tunnel construction, Drilling, Drilling equipment, Tunneling machines, Rock bolts.
Identifiers: *Tunneling methods, *Tunneling controls, Concrete lining, Laser beams.

Improvement in methods and equipment during the past 15 years have kept tunnel excavation costs from appreciable increases while the general construction cost index has doubled. Tunnel drilling rates have increased from 20 ft per week 100 years ago to 100 ft per week 50 years ago and to about 300 ft per week today. A milestone in tunnel driving was the 3 1/2 mile-long Fucius Tunnel (19 ft wide and 9 ft high) started in A.D. 41 and requiring 30,000 slaves 11 years to complete. The concept of boring machines to drill tunnels goes back to 1882, but the greatest advance has been made in the last five years. A table lists the major completed mole tunneling projects. Cost savings up to 40% over conventional drill-shoot-muck cycle methods can be proven. The requirement for and types of tunnel supports being used are analyzed. A laser beam is an excellent control method for precision drilling with a boring machine. Tunneling safety has progressed to a satisfactory level. During a million man-hours at Blanco Tunnel, Colorado, only six minor lost-time accidents occurred.

173
HOW DILLINGHAM RECONSTRUCTED MAJOR VICTORIA TRUNK SEWER SYSTEM,

G. Beardsley
Eng Contract Record, Vol 84, No 2, pp 40-41, Feb 1971.

Descriptors: *Sewers, *Tunnels, *Pumping plants, *Tunnel construction, Tunneling, Costs.
Identifiers: *Reconstruction, *Canada.

Reconstruction of Greater Victoria's Northwest trunk sewer system, a $2,148,000 contract awarded to the Dillingham Corporation, is approaching completion. Work of constructing the expanded facility combines two different types of tunnel work: open cut and reusing the existing tunnel, and building the necessary pumping and monitoring stations. A new tunnel was needed for 220 feet in areas too deep for open cut and where the original tunnel was through clay and had subsided. This section of the tunnel is a 72-inch diameter steel primary liner plate with a poured concrete invert and a secondary lining of shotcrete. Hand mucking and installation of 18-inch steel liner plate sections was the method used for tunnel advance. The

upper end of the trunk system is a 550-foot inverted siphon consisting of twin 24-inch diameter PVC pipe while at the downstream end of the trunk a main pumping station has been built to force the flow through the extended outfall. Construction of the pump station required the excavation of 2300 cubic yards of rock and it contains equipment for comminuting the sewage, measuring the flow, and logging data obtained from other pump stations and metering points in the system.

174
DESIGNING THE LININGS OF PRESSURE TUNNELS IN ANISOTROPIC ROCK,
Bureau of Reclamation, Denver, Colorado

V. S. Eristov
Bureau Rec Translation No 740, Mar 1970. 11 p, 3 fig, 4 ref.
Translated from: Gidrotekhnicheskoe strortel'stvo, No 3, pp 28-31, 1965.

Descriptors: *Underground structures, *Rocks, *Pressure tunnels, *Tunnel linings, *Tunneling, Elasticity (mechanical), Anisotropy,

Formulas are derived for the stresses and radial deformation of a pressure tunnel lining in anisotropic rock using the theory of elasticity. The surrounding rock is assumed to be transformed into a monolithic elastic medium by grouting. It is shown that it is possible to consider, with small error, only radial components of deformation and elastic resistance. By using a constant coefficient of elastic resistance, the formulas are transformed into the formulas for an isotropic medium. The deformations obtained by these formulas for a thin lining coincide reasonably close with the corresponding deformations for an opening in an orthotropic medium loaded along the contour with a uniform radial load. An example calculation is given.

175
TUNNEL BORING TECHNOLOGY, DISK CUTTER EXPERIMENTS IN SEDIMENTARY AND METAMORPHIC ROCKS,
Bureau of Mines

Roger J. Morrell, William E. Bruce, and David A. Larson
Report of Investigation No 7410, Jul 1970. 32 p, 12 fig, 6 tab.

Descriptors: *Tunnels, *Boring, *Rocks, Excavation.
Identifiers: *Subsurface structures.

Disk-cutter experiments were performed on five rock types ranging in compressive strength from 9.000 psi to 27.000 psi. A specially constructed testing machine called a linear-cutter apparatus (LCA) was designed to load and traverse a free-rolling disk cutter across a sawed rock surface. The LCA was instrumented to measure the vertical and horizontal forces acting on the cutter during the run. The ability of disk cutters to fragment rock was determined for both 60-degree and 90-degree cutting-edge angles, and relationships and regression equations were developed to predict cutter performance based on rock physical properties and applied forces.

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JOURNAL LIST

	Abbreviation	Full Title
1.	Am City	American City
2.	Ber Inst Wasserwirt Gesundheits-ingenieurwesen	Berichte der Institute Wasserwirtschaft Gesundheitsingenieurwesen
3.	Construct Methods Equip	Construction Methods and Equipment
4.	Delaware Valley Ind	Delaware Valley Industries
5.	Effluent Water Treat J	Effluent and Water Treatment Journal
6.	Eng Contract Record	Engineering & Contract Record
7.	Eng News - Record	Engineering News - Record
8.	Gas- Wasserfach (Wasser/Abwasser)	Gas- und Wasserfach (Wasser/Abwasser)
9.	J Construct Div, Am Soc Civil Engrs	Journal of the Construction Division, American Society of Civil Engineers
10.	J Hydraulics Div, Am Soc Civil Engrs	Journal of the Hydraulics Division, American Society of Civil Engineers
11.	J Hydrol	Journal of Hydrology
12.	J Inst Munic Engrs (London)	Journal of the Institution of Municipal Engineers (London)
13.	J Water Pollution Control Fed	Journal of the Water Pollution Control Federation
14.	Machine Design	Machine Design
15.	Public Works	Public Works
16.	Surveyor	Surveyor
17.	Wasserwirt	Wasserwirtschaft
18.	Water Resources Bulletin	Water Resources Bulletin
19.	Water Sewage Works	Water and Sewage Works
20.	Water Spectrum	Water Spectrum
21.	Water Wastes Eng	Water and Wastes Engineering

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11022 --- 08/67	Phase I - Feasibility of a Periodic Flushing System for Combined Sewer Cleaning
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11024 FKN 11/69	Stream Pollution and Abatement from Combined Sewer Overflows - Bucyrus, Ohio, (DAST-32)
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11000 --- 01/70	Storm and Combined Sewer Demonstration Projects - January 1970
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